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COSMOPOLITAN EARTHWORMS

– an Eco-Taxonomic Guide to the Peregrine Species of the World

6th Edition

by

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"BUDDEROO worm" from *Eucryphia* July, 2001.

"*Sine systemate chaos*"

Quote from titlepage to *Das Tierreich. 10. Vermes* (Michaelsen, 1900).

www.archive.org/details/oligochaeta10mich

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(This is the final edition, any changes will now be updated versions to 6th Edition).

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ISBN: pending as not mandatory for non-paper publications in most regions.
[Possibly compliant with ICZN (1999: Art. 8), several copies of identical CDs are lodged in public libraries eg. Natural History Museum London, YNU, Australian Museum, Uni NSW, Kyoto Uni., UWA, Uni. Vermont, SA, etc. thereby likely validating nomenclatural acts not formally published elsewhere].

"*The beginning of wisdom is to call a thing by its correct name*" – Chinese Proverb.

"*Man is certainly stark mad; he cannot make a worm, and yet he will be making gods by dozens*." – Michael de Montaigne (1533-1592), Apology for R. Sebond. xii.

"*We are all worms, but I do believe that I am a glow-worm*." – Winston Churchill.

"*... ignorance more frequently begets confidence than does knowledge ...*" – Charles Darwin (1871): *The Descent of Man*.
"***I neawly made a mistake once***" – a confident Professor I once met (who also said: "*How dare you question me! I am a pwofessor*!").

"*...An error doesn't become a mistake until you refuse to correct it*." – JFK.

"***the Most Important Animal in the World***" Friend Earthworms by G. S. Oliver, 1941.

"..***none is more important than the earthworm***" Silent Spring by Rachel Carson, 1962.

'When the question is asked, "*Can I build top-soil*?" the answer is "*Yes*", and when the first question is followed by a second question, "*How?*" the answer is "*Feed earthworms*"' – Lady Eve Balfour's intro to Barrett's *Harnessing the Earthworm*, 1947

Suggested citations of previous works and current publication:
* Blakemore, R.J. (**2002**). Cosmopolitan Earthworms – an Eco-Taxonomic Guide to the Peregrine Species of the World. VermEcology, Kippax, Australia. Pp. 426 + 80 Figs.
*Recommended text for '*Soil Quality, species determination*' by ISO/FDIS 23611-1: **2006 and "*Tropical Soil Biology*" (Eds. Moreira *et. al.* 2008: 48).**

Blakemore, R.J. (**2006**). *Op. cit.* (2nd Edition). VermEcology, Yokohama. [August, 2006].
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Blakemore, R.J. (**2010**). *Op. cit.* (4th Edition). Pp. 750 +~350 Figs. & links. [Dec., 2010].
Blakemore, R.J. (**2012**). *Op. cit.* (5th Edition). Pp. 850 +~350 Figs. & links. [Dec., 2010].
Blakemore, R.J. (**2016**). *Cosmopolitan Earthworms – an Eco-Taxonomic Guide to the Peregrine Species of the World*. (6th Edn.). VermEcology, Yokohama, Japan. Pp. ~980 +~350 Figs. & Internet links. [2016].

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Acknowledgements, Dedications and Disillusionment

This work is in tribute to luminaries and predecessors of earthworm studies, especially:-

Mr **Charles Darwin** (1809-1882), a fellow Salopian, detailed observations over 40 yrs (e.g. Darwin, 1838; 1840; 1881) spurring ecological interest in the humble earthworm. As with *Origin of Species* (1859), through meticulous observation he again showed in *Worms and Vegetable Mould* (1881) that "*small causes produce great effects*". He thought the powerful earthworm could revolutionise the world (Ref.).

Prof. **Johann Wilhelm Michaelsen** (1860-1937) whose invaluable opus, *Das Tierreich* (1900) heralded an era of stability in systematics and understanding of the oligochaetes: in 211 papers (or here) from 1885-1938 he named 1,083 earthworm spp.

Lt.-Col. Dr **John Stephenson** M.B., D.Sc, F.R.S (1871-1933), an industrious (ca. 250 spp), and wide-ranging (e.g. Arabic translations) researcher, dedicated his enduring monograph, *The Oligochaeta* (1930), to "*W. Michaelsen, - my Friend and Master*".

Dr **Ken Lee** (1927-2007), eminent in the science of taxonomy as well as the broader field of Ecology (e.g. Lee, 1959; 1985; Lee *et al.*, 2002). My PhD advisor and assessor, he very generously, he passed down to me his own annotated copy of Michaelsen's *Das Tierreich* given him by **Sir W.B. Benham**, another early hero of earthworm work.

Gordon Enoch Gates (1897-1987), an American schoolmaster in Burma in 1930's, was a prolific taxonomist (ca. 369 names, but not all valid) with publications span from 1925-1982 (see Appendix). Although a critic of the 'Classical System', yet his *Burmese Earthworms* (1972), was dedicated to both W. Michaelsen and J. Stephenson.

Dr **Reginald William Sims** & Mr **Ed Easton**, ex British Museum, who took the challenge of trying to clarify the confusion into which earthworm taxonomy languished (largely due to Gates and his followers) after classical era of Michaelsen & Stephenson.

My own work was encouraged by friends, family (J.E. Blakemore 1928-2007), and concerned colleagues around the world. Thanks in particular to the McInnes family of Canberra who kindly loaned their Broulee beachhouse for compilation of early manuscripts. Christine Godden helped keep the initial project on its feet, and Yuko Hiramoto the current efforts. Much of this work has been self-funded (hence the need to charge) as little official interest was found in numerous grant applications that were given low priority*. However, I do appreciate whatever support that was provided and, as usual, my thanks also go to the collectors of the worms, across time and place.

*We may ask "*What is the economic value of a species*"; the real answer is that each is priceless because they are irreplaceable if lost through extinction, however, more mundate costings put the tax deduction value of a holotype specimen donated to an Australian institution at about $900, whereas some institutions charge much more for the mere convenience of the naming rights, before anything is known of ecology, e.g.:

1. Although the Scripps Institution of Oceanography supports 2,000 staff with $189M Research expenditures (FY 2012-13), it recently offered marine worm names for sale at $5,000-50,000 each (https://scripps.ucsd.edu/news/2474).
2. On 29/9/2009 Australian Minister for Environment (PG/344) announced $90,000 p.a. for 3 yrs to describe ~20 marine worms (i.e., ~$13,500 per worm - http://cutlass.deh.gov.au/biodiversity/abrs/funding-and-research/creefs-grants/index.html).

It is important to bear in mind that there is little to zero funding for Soil Biodiversity research in contrast to astronomical financial distraction for Space or Marine Biology**, neither of which is sustainable should our soils collapse which itself may be imminent due to loss of soil biodiversity – especially of the vitally important earthworm populations – caused by human activities summarized in the acronym HIPPO which stands for **H**abitat destruction, **I**nvasive species, **P**ollution, **P**opulation, **O**ver-harvesting. To this we may add human **I**gnorance, **I**ndifference, **I**ndulgence and **I**nsatiability.

Note that just **0.06% of human food comes from the Ocean or aquaculture combined, the remaining 99.04% from Soil [e.g., FAO/ALG (2004); FAO, 2017 www.fao.org/soils-portal/soil-biodiversity/soil-conservation-and-agriculture/en/] thus there is very little justification for marine research and none for space exploration as a priority. Soil is also the most degraded and most manageable resource. A new Planetary Triage is needed to justify funding for most essential science as a priority over "non-essential" academic indulgences that can wait until the ecological crises abate.

Dedicatio:

Herr Prof. Johann Wilhelm Michaelsen {9th Oct. 1860- 18th Feb. 1937}. Photo courtesy. Oligochaetologist and author of >1,083 taxa; he joined Hamburg University Museum in 1887 and worked there as Curator until passing away in 1937; his 212 papers (1885-1938) are listed online: here. He was a contemporary and associate of Dr John Stephenson {1871-1933} and both seemed to have shown mutual admiration and respect, as noted above, e.g. Michaelsen's (1934) dedication to Stephenson reads: "*I shall dedicate the first new species of the present collection to the manes of our dear late colleague, who will never die in the memory of his fellow-workers, and whose scientific work will endure as long as men devote themselves to our special science.*"

The paper by Michaelsen (1903) was dedicated to "*Meiner lieben Frau Agnes*".

Michaelsen was also a friend and colleague (Omodeo, 2000: 179) of Dr Alfred Lothar Wegener {1880-1930} who completed his PhD at Berlin University in 1904/5 before moving to Marburg where, in 1911, he formulated his theory of Plate Technonics that he developed into a book while recuperating as a casualty of the Great War in a military hospital in 1914/5. After the war he succeeded his father-in-law, Wladimir Köppen, as director of the meteorological research at the Marine Observatory near Hamburg. In 1915 he first produced "The Origin of Continents and Oceans" drawing heavily on Michaelsen's biogeographical work (e.g. Michaelsen, 1903 noted above). Michaelsen (1922) published a review on earthworms and Tectonics and, appropriately, named a genus in his honour as *Wegeneriella* Michaelsen, 1933.

A 50-year "*Wilhelm Michaelsen Memorial*" International Symposium on Terrestrial Oligochaeta was held in Hamburg on Sept. 14–18th 1987 (Published 1987).

In jar of types borrowed from Hamburg, I found a red eyelash that may be his... [A picture in circulation claiming to be of him as a younger man is actually of a relative Georg Wilhelm Michaelsen (born 27th May, 1844) who married Helene Ebeling (Ref.). Rather than our Johann Wilhelm Michaelsen who married Agnes Huwald and was one of seven children of Friedrich Rudolph Michaelsen (5th Jan., 1813-1902) and first wife Johanna Catharina Ferdinandine Koehn (16th Jan. 1826-1900) who married 28th June, 1846, but apparently our Wilhelm and Agnes had no children themselves (Ref.). See - https://vermecology.wordpress.com/2017/10/12/doppelgangers/].

In comparison to the late Drs Michaelsen, Stephenson, Wegener and Lee, most subsequent worm workers are cast in a mean, dull light and at times appear either delusional or deceitful, and, not infrequently, both of these. It's the petty politics of scientific egos (and scrabbling for funds!) vs. the honest search for scientific Truth.

In this regard, true Scientists can only have one Master, and that is Truth.

Disillusionment comes from a realization that not all people who call themselves 'Scientists' work for Truth, some (how many?) cynically and with great smallness produce poor work just for Money and Ego instead (some obliged to publish one or two papers per year to keep their jobs). To those who keep themselves uninformed we must conclude the question, paraphrasing from my Permaculture mentor, Dr Bill Mollison:

"*Either they are illiterate or just plain stupid?*"

If they claim in answer "*Neither*", we can know that such shameless people wilfully ignore correct information and thus are truly & deliberately Ignorant which is so shameful and almost inexcusable.

But, as Hanlon's Razor reminds us:

"*Never attribute to Malice that which can be adequately explained by Stupidity*"

And, as John Keats tell us,:

"*"Beauty is truth, truth beauty," – that is all*

Ye know on earth, and all ye need to know."

As another aside 'rant': Darwinian Natural Science is synecdochical in that complete understanding of the smallest part must explain its all, and its universal Laws or Truths are global so as to yet explain operations even in greatest ecological complexities. Moreover, or, rather, conversely, if Science is false or dishonest in its smallest part, it is wholly discredited (egotistical scientists again take note!).

Preface to Editions

"*To see a world in a grain of sand and a heaven in a wildflower*." W. Blake (*Auguries*).

'*Angels of the earth*' is one translation of the Chinese characters for earthworms (left – translation from my colleague Dan-Jing Zhou in 1992). The classical Chinese "Book of Songs", supposedly compiled by Confucius (551–479 BCE), mentions worms as do works by philosophers Mengzi (372 – 289 BCE) and Xunzi (c. 310-219 BCE) who in 'Encouraging Learning' observed:

> "*Earthworms lack the power of sharp claws or teeth, or strong muscles or bones, yet above ground they feast on the mud, and below they drink at the yellow springs. This is because they keep their minds on one thing*."

Seeing a worm turned up by the plough and eaten by a bird started seven-year-old Prince Siddhartha (Gautama Buddha) on his contemplative path to understanding the Cycle-of-Life. The earlier inhabitants of India, the Santals, have a creation myth in which the 'King of the Earthworms' formed land on the back of a giant turtle. In the Classical world, the 'Father of Biology', Aristotle, called them the soil's entrails [hence Savigny's genus name *Enterion*], and it is reported that Cleopatra decreed them sacred in ancient Egypt (although this may have been a reference to the use of the term 'worm' for snakes?). Despite this interest, Leonardo da Vinci ca. 1500s told us that: "*We know more about the movement of celestial bodies than about the soil underfoot*". One of the first books printed in English was by the Prioress of a Nunnery: Juliana de Berners' *Fysshynge with an Angle* [a hook] (1496), and Izaak Walton's *Compleat Angler* (1653) also praised different kinds of baitworms. It was further explained by Gilbert White (1770) that earthworms don't just serve fisher-folk: known as the 'Gardner's Friend' they play a vital function in a most popular and enduring human activity, gardening (a full citation is given in an Appendix). From his childhood in Shropshire, Charles Darwin described himself as "*humane*" and to save causing a bait worm to suffer he learnt to kill them first by immersion in salty water and he "*never spitted a living worm, though at the expense, probably, of some loss of success*". And, while gardners and anglers appreciate worms to a certain degree, a birdwatcher gets excited about a few kilograms of birdlife or the grazier is concerned about a couple of 100's kg per hectare of pasture livestock but they almost totally overlooke an underground biomass of earthworms, often far in excess of those living overhead, totaling as much as five tonnes

per hectare. The health of these earthworms is crucial to the well-being of bird, beast, and human – as Rachel Carson cogently explained in her book *Silent Spring* (1963). She said: "*Of all the larger inhabitants of the soil, probably none is more important than the earthworm*."

It is in the formation and maintenance of fertile soils, plus contributing to the recycling of organic matter, that earthworms have performed their most beneficial roles. The diverse arrays of earthworm species existing today have withstood every kind of ecological, environmental and climatic catastrophe in their long evolutionary history. Nevertheless, some human activities can unintentionally and abruptly terminate these natural processes and are known to have caused extinction of several species [e.g., *Hypolimnus pedderensis* see IUCN Redlist, species=41254 May, 2004 from Tasmania; 2008 and *Tokea orthostichon* (Schmarda, 1861) plus about another dozen species from NZ – see Blakemore (2012) and at least *Amynthas habereri* (Cognetti, 1906) plus several others from Japan {e.g. *A. japonicus*!}. Note: *Driloleirus americanus* Smith, 1897, the "Giant Palouse earthworm" or "Washington giant earthworm" previously considered extinct, it has recently been rediscovered by University of Idaho researchers although its conservation has been controversial (Leon & Maynard (2009). *Driloleirus macelfreshi* (Smith, 1937) the "Oregon giant earthworm" feared extinct in the 1980s has since been found (e.g. Fender & McKey-Fender, 1990). Presumed extinct Brazilian giant *Rhinodrilus fafner* Michaelsen, 1918 was rediscovered in 2011].

Two anecdotes will serve to illustrate the kind of damage inflicted: Mr Keith McIntyre, a farmer from Jondaryan on Queensland's Darling Downs, told me that when the natural grasslands there were first cultivated such a mass of earthworms were exposed that they had to be shaken from the cultivator tynes at the end of each run, and their blood pooled in hollows. Possibly the species involved was *Heteroporodrilus bongeen* Blakemore, 1994 which now seems to persist only a roadside verge next to a junior school.

The second story was told to me by veteran canegrower, Mr Frank Tarditi, who lives between Innisfail and Tully in tropical NE Qld. As a child, he saw large flocks of Ibis (*Threskiornis* spp.) foraging behind tractors ploughing the canefields, but now rarely even one which may give a desultory look at the lifeless soil before flying off to find better fare. Indeed, my own surveys found that whereas earthworms may thrive in adjacent lands, little or no subsoil faunal activity occurs in areas subjected to biocide treatments aimed at insect

pests or fungal pathogens such as under established canefields and in non-organic citrus orchards or vinyards. Conversely, an organic farm in Ibaragi using okara 'waste' as fertilizer had an abundance of earthworms so the farmer could easily sink a two meter bamboo pole into the soil without effort while I found it difficult to sample adjacent fields.

Many early cultures appreciated qualities differentiating various kinds of worms they used for medicines or as food, for example Australian Aboriginals, New Zealand Maori and native North Americans (Beddard, 1912; Stephenson, 1930), although it was not until the publication of Carl von Linné's (1758) 10th edn. of *Sytema Naturae* that we had the first scientific names. Earthworms are classed as Oligochaeta (having few bristles), as opposed to the mainly marine Polychaeta (with many bristles). In Linnaeus's day, all earthworms were lumped under *Lumbricus terrestris* – the 'Worm of the Land'. Having only one 'common' earthworm sufficed until 1826 when Napoleon's savant on his Egypt Expeditions, Frenchman Marie Jules César Lelorgne de Savigny, (1777-1851), astonished the scientific world by describing a multiplication of 20 odd species from his Paris environs. Currently, about 10,500-11,300 oligochaetes species in ca. 804 genera of 38 families are extrapolated from the INHS website (May, 2006) with perhaps ~30% comprising enchytraeid and aquatic microdrile cousins of 'true' earthworms. Terrestrial megadrile earthworms total ca. 7,000 named species (Cs. Csuzdi, pers. comm. - see, Blakemore 2007, 2008; and Csuzdi, 2012), and while names are continually added the more we search and discover, probably only ~20-30% of all species are currently described. Numbers of synonyms are yet unestimated while claimed extraction of "cryptic species" needs ICZN clarification.

It is interesting that both major proponents of Evolutionary Theory studied worms: my fellow Shropshire countryman, Charles Darwin (1809-1882), researched earthworm ecology while the penchant of his predecessor, Jean-Baptiste Pierre Antoine de Monet, Chevalier de Lamarck (1744-1829), was microdrile systematics. Lamarck coined terms '**Biology**' for study of living things; **Annelida** for segmented worms; and '**Invertebrata**' for the 99% of animals on the planet that, like worms, lack a spine.

He said: "*...we should chiefly devote our attention to the invertebrate animals, because their enormous multiplicity in nature, the singular diversity of their systems of organization, and of their means of multiplication, ... show us, much better than the higher animals, the true course of Nature, and the means which she has used and which she still unceasingly employs to give existence to all the living bodies of which we have knowledge.*"

Origins of my interest in earthworms stem from my BSc Honours project in 1980/81 comparing soil-fauna beneath organic and conventional agricultural sections of the pioneering '*Haughley Experiment*' in Suffolk, UK. Intended to mark the Centenary of Darwin's 1881: "*The Formation of Vegetable Mould Through the Action of Worms*", and despite showing highly significant results, the project report went unpublished for 20 years (Blakemore, 1981; 1996; 2000). What convinced me then of the importance of earthworms, at least as monitors of soil health, was that Haughley farm showed earthworm populations transformed by management regimes. A most startling finding was that whereas soils from the organically managed fields were loose and friable, even during a cold wet January, those in adjacent intensive arable fields were difficult to walk over as they were puddled with a sticky mud that clung my boots. Particularly unexpected data was that soil in the organic field was not only darker and less compact, its **soil moisture and temperature were also higher** compared to adjacent fields measured at the same time on the same day!. This study further showed for the first time that behaviourly worms prefer organic soils when offered a choice. Moreover, later PhD studies (Blakemore, 1994) demonstrated that earthworms build fertile soils with healthy charecteristics thereby encouraging plants in a mutually reinforcing way.

After a decade hiatus in Japan, London, Scotland and Sydney, my studies continued with RIRDC funded PhD research at CSIRO Division of Tropical Agriculture, Brisbane from 1991-1993 with Dr Ken Lee as my mentor and inspiration. The core of the current work is taxonomic sections of the resulting Thesis (Blakemore, 1994a), expanded to describe all 150 or so most common exotics encountered around the World. These comprise ~50 Megascolecidae (mainly pheretimoids), 50 Lumbricidae, with the remaining 50 odd species from ten other families. These then are the eponymous **Cosmopolitan Earthworms** as titled in this work.

Although an Ecologist by vocation and training, due to the many inconsistencies and omissions in the identification of species (the basic entities of any ecosystem), I became involuntarily drawn into the 'black hole' of taxonomy. While classifying field samples from my agro-ecological surveys in Australia, I unearthed many specimens that did not agree with any earlier descriptions (even allowing for many earlier mistakes!). Separating exotic from native and trying to find their correct names, or creating new names for unmatched taxa, consumed much time and effort – and a primary aim with

this ***Guide*** is to save others such an ordeal.

Always my intention is to produce keys and figures that will enable easy specimen comparision and guide the novice via the quickest, yet surest, route to the correct answer, or at the very least to point the reader in the right direction. Some earlier authors (and not a few current ones) seem to delight in making descriptions and figures as scattered, irrelevant and undecipherable as possible, possibly in an attempt either to make out the work is more complex than it needs to be or to protect their 'claim' on a particular working group. Whereas I personally encourage co-operative collaborations, not just for mutual benefit, but also for the benefit of 'user clients' - those ecologists who just want a current and stable name for their worm study subjects.

My subsequent earthworm projects included surveys and revisions of the faunas – from the tropics to sub-Antarctic islands of the Southern Ocean and the Arctic Circle – of Australia/New Zealand, Japan/Korea, Taiwan, SE Asia & India (including Sir Albert Howard's original Indore vermicomposting facility visited 20th March, 2016); incidental studies have concerned species from the Americas, Europe, Asia and the Pacific but less so those from the Middle East and Africa. This work has resulted in descriptions of around 1,000 earthworm taxa – ca. 350 new to science – the discovery of the first instances of about 150 exotic species, as well as a taxonomic revision of all 20 World families (Blakemore, 2000; 2013) and compilation of species checklist for most regions that are freely accessible online (e.g. Blakemore, 2007, 2008). Some names have been lost to syonymy and I have personally confirmed two extinct species (in Tasmania and NZ listed in IUCN Redlist) and suspect dozens more (e.g. in Japan).

Yet it is not always necessary to travel to find exotic earthworms – many of the exotics from around the globe may just as easily be obtained locally. I recommend the reader test this biodiversity by taking a garden fork and conducting a 'backyard safari'. Rather than stifle further inquiry, it is hoped this ***Guide*** to common peregrine species will stimulate interest and facilitate continued study of these fascinating, yet often neglected, 'angels of the earth'. There is still much more to learn than is known.

To you then, the next generation of researchers, and quoting slightly out of context the Clown from Shakespeare's *Anthony and Cleopatra*:

"***Yes; forsooth; I wish you joy of the worm.***"

R.J.B., Broulee, 10th May 2002, Yokohama 13th Dec. 2006, WA 2008, Japan 2010-2024.

Preface to 5th & 6th Editions (after which only new versions will occur)

A dozen years on from COSMOPOLITAN EARTHWORMS 1st Edition many improvements and enhancements are made to this ***Guide***. Nevertheless, it is inevitable that unintentional omissions and typos remain (some due to my wayward Japanese PC refusing to compile such a long document, or SpellCheck partly 'correcting' to American English). I trust you, the reader, will allow for such instances and assist me in keeping the text up to date by emailing any oversights. Initially based on my "**peer-reviewed**" PhD thesis [but see Horton (2000) for discussion of peer review misuse; Ref.], this Edition corrects several errors & omissions plus it provides a general expanded update, now for ~250 exotic spp. Despite its urgency, Soil Ecology has sadly lost out progressing little in the last few years.

As ecological and taxonomic data become more readily available online – including many historical/Classical papers – contradictions and superseded names persist. Nomenclatural sense, stability, universality and consistency requires a taxonomist to make necessary corrections as soon as practical after these are noticed. Where possible, I will incorporate such updates into my various species checklists and hopefully I can continue to make these accessible and searchable via the Internet [e.g. Earthworm information at Annelida.net] as well as in future Editions of the ***Guide***.

A more sensible, pragmatic solution for taxonomic stability avoiding mistaken data repeat, would be collaboration to design and implement a single, unified source database with key information compiled by consensus (ideally based on mtDNA COI barcoding of small tissue samples from 1° types!) that may be accessed freely. In this model, a species' nomenclatural, ecological and distribution status would be consolidated and regularly maintained to ensure it is complete and correct, current and convenient. Only then will taxonomy provide the professional service to field workers that it aspires to.

The ideal of an Online Standard Nomenclature on both sides of the Altantic and Pacific Oceans (not to mention the English Channel or Sea of Japan!) needs to be realized. If we strive for it, I think this ambition is entirely achievable, and in a short space of time. In the meantime, and in lieu of any other comprehensive guide to all the World's exotic earthworms, and not just the few species that are easy to identfy, please enjoy COSMOPOLITAN EARTHWORMS 6th Edition and accept it as a work-in-progress, a taxonomic 'snap-shot' of current status, and as a stepping-stone to more solid ground into the future.

R.J.B. Yokohama, 2002-2018; Zama >2018...

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1. GENERAL INTRODUCTION

"*The importance of taxonomy is clearly recognized by the majority of scientists and without reliable taxonomy, ecological studies are irrelevant*"

Dominguez *et al.*, 2005 (*Pedobiologia*, 49: 82).

[And although I disagree with their particular study result, to this sentiment I would add: "*just as taxonomy without a grounding in Ecology is pointless*"].

Background

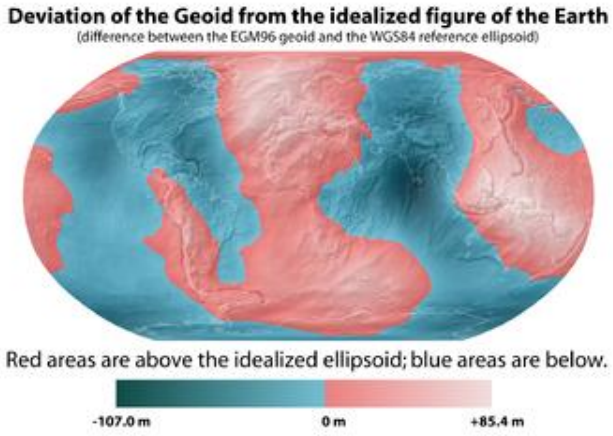
It is necessary to start by defining the relative merit and importance of Earthworms. Their intrinsic value (i.e., the value in and of themselves) is that of all other natural organisms, but their contribution to Life on Earth is crucial and chronic and colossal. Approximately 99.7% of our food and all timber/fibre is produced on land – from soil, the domain of the worm – and only 0.3% comes from oceans and other aquatic ecosystems combined (FAO/AGL - www.fao.org/ag/AGL/agll/soilbiod/consetxt.stm). A colleague working on Algae, perhaps the most important of plant groups, told me that oxygen in every second breath is the product of marine micro-algae; this also implies that the balance of O_2 in every first breath is produced by plants on land that our worms help grow. (Incidentally, the ocean's O_2 contribution is much exagerated).

Just 11% of the Earth's terrestrial surface is habitable and cultivated and, of the total available, approximately 40% of agricultural land is seriously degraded, according to the UN's Millennium Ecosystem Assessment (MEA, 2005 www.millenniumassessment.org/documents/document.300.aspx.pdf). Nett topsoil loss by erosion (water, wind, tillage) is estimated by FAO (2015) at 25-40 billion tonnes per year with mean 32,500,000,000 t per yr (or about -33 Gt/yr topsoil loss). A year has 31,536,000 seconds. Thus about 1,000 tonnes of topsoil is lost every second.

How important is of loss of topsoil? Consider a desert; basically without fertile topsoil there is little plant growth and almost no life on land. How big an issue is it? The 1991 UN funded Global Survey of Human-Induced Soil Degradation Report (GLASOD www.isric.org/UK/About+ISRIC/Projects/Track+Record/GLASOD.htm) showed significant problems in virtually all parts of the world. The MEA, which despite its scope did not consider 'Soil Systems' separately, nevertheless ranked land degradation among the world's greatest environmental challenges, claiming it risked destabilizing societies, endangering food security and increasing poverty.

My 2018 paper - www.mdpi.com/2571-8789/2/4/64/htm reveals extent of land.

It is often said that this planet is 70% ocean with the implication that Marine Research deserves the bulk of funding resources and research effort. Actually this is a false perception: Superficially the surface may appear mostly ocean, but the Ocean is flat while the Earth is, rather obviously, not flat:- it is hilly (mean height amsl 840m). Thus actual surface area (exposed to Sun) proportions are closer to >50:<50 Soil:Sea as shown by the latest satellite and computer data from US military NGA site and summarized in the following figure from Wikipedia (Ref.):


Deviation of the Geoid from the idealized figure of the Earth
(difference between the EGM96 geoid and the WGS84 reference ellipsoid)
Red areas are above the idealized ellipsoid; blue areas are below.
-107.0 m
0 m
+85.4 m

To me this figure implies that potentially 50% of the surface of the earth is above the actual mean sea-level geoid. This depending upon the unit of measurement: that at 1 m scale obviously giving less land proportion to that at decimeter or 1 cm scales it is infinitely larger and becomes >70% land. However, irrespective of relative physical areas and volumes, the total arable land is just 13.3% of the land's surface, with only 4.7% supporting permanent crops. So we all depend on probably less than 5% of what land there is for the bulk of our basic survival needs.

In contrast, the oceans are relatively biologically poor, due partly to the mixing by currents, and only the coastal, continental shelf has high biodiversity and abundance – this because of run-off of nutrients (and pollutants) from the soil – and even CoML acknowledges (www.coml.org/census-framework) that only their coastal fringe is biodiverse: "*While the shelves comprise only 10% of ocean areas, they contain most of the known marine biodiversity"*. Further out is what is called the "*open-ocean desert*".

An iBOL website summary reports an ocean fauna of just ~230,000 species (http://ibol.org/wg-1-8-marine-bio-surveillance/), the biota updated by the hugely costly ($700 million plus for 2,700 scientist) http://www.coml.org/. But the actual figures they quote are poor: the CoML summary (2010) says "*It upped the estimate of*

known marine species from about 230,000 to nearly 250,000. Among the millions of specimens collected in both familiar and seldom-explored waters, the Census found more than 6,000 potentially new species and completed formal descriptions of more than 1,200 of them." This means that only 1,200 new species were actually described with the remainder (4,800?) currently unnamed. Cost per completed an outrageous $580,000 per new species!

Moreover, their total figure is abysmal: marine organisms are just 10% of known species (i.e., 90% are from soil!) and just 2% compared to the lower global estimate of 10-60 million spp – most of these being from the soil and most completely unknown. This is partly because there is ease of movement in the water medium via oceanic currents allowing intermingling which is one reason why marine worms make such poor biogeographic models while earthworms, which are ancient, diverse, and highly endemic – most being confined to their continents and area of origin (except for the 150 Cosmopolitan species dealt with here) – are most excellent model organisms despite taking some physical spade work to unearth. Thus the land has the marority balance of the 10-60 million anticipated species with an estimated total of just 2 million taxa currently catalogued during the last 250 years since Linnaeus.

The soil habitat is particularly diverse with a each handful of topsoil containing tens of thousands of species, most totally unknown and undescribed. Thus soil is well labeled the "*poor-man's rainforest*" and the journal Science, realizing that our knowledge is so scant, produced a special 2004 issue entitled: "*Soils – The Final Frontier*" (http://www.sciencemag.org/content/vol304/issue5677/#special-issue).

It is a mystery why governments and Academia expend precious funds and brain resources on vain discovery of useless planets overhead or new deep-sea species that will still be there tomorrow, while vital unrecognized organisms literally beneath our feet disappear at an increasingly alarming rate and to our peril? Such astronomical costs and abysmal efforts would be much more justified if directed on more grounded and down-to-earth projects such as soil eco-taxonomy and biodiversity.

Why are we not concentrating our efforts and valuable resources on protecting and preserving the tangible deeds of our earthly home patch for the future? Where on earth is there a "***Soil Ecology Institute***" equivalent to myriad Space Observatories and Marine Labs?

It is as if our house was on fire and either through distraction or displacement behaviour we decide to feed the pet goldfish and go star-gazing rather than tackle the

imminent issue at hand – the elephantine inferno in the living room. All Science is not equal, and we desperately need a kind of **triage** to prioritize crucial issues in a timely manner based on their urgency. Wheeler (2004) has also advocated for Taxonomy Triage.

On an economic value basis, soil biodiversity has both direct (the organisms themselves and/or their metabolic products) and indirect (the long-term outcome of their activities) benefit. It is estimated that the value of ecosystem services provided each year by soil biota in agricultural systems worldwide (e.g., organic waste disposal, soil formation, N_2 fixation, bioremediation and biocontrol) may exceed US$1.5 trillion (by AGL/FAO as modified from Pimentel *et al*., 1997). Earthworms are the main governors of soil biology and as such they rightly deserve special attention for without them the soil diversity is poor and the soil-food-web interactions weak.

Drawing a comparison between the value of ecosystem services provided by biodiversity and the cost of implementing biodiversity protection policies, the authors of a 2008 study established a marginal value of biodiversity to Ireland of at least €2.6 billion per annum. An example in the report estimated that the value of the humble earthworm to Ireland to be in the region of €700 million per annum for the services it provides in removing dead matter and releasing nutrients back to the soil. It was emphasised that the value of €2.6 billion suggested by the report was a conservative estimate and that the true value was likely to be much higher if you considered other areas such as the benefits to human health. In comparison, the 2010 European 'bail-out' for the Irish Republic was worth about €85bn ($113bn) equivalent to about 33 years of environmental benefit by these highly conservative and skewed calculations.

Whereas 'Wall Street' and the financial sector during the 2008/9 crash lost ca. $1-1.5 trillion, the stark reality is that at today's rate we are losing natural capital at ca. $2-5 trillion each and every year, equating up to 7.5% of global GDP. This data is extracted is from UN-backed TEEB reports (http://www.teebweb.org/ see also editorials by BBC here: http://news.bbc.co.uk/2/hi/science/nature/7662565.stm), where it is argued that contamination of water supplies, the loss of productive land through soil erosion and drought, and disruption to supply chains caused by deforestation and overfishing all result in multibillion-dollar costs that are largely ignored by the current global economic system (but note fish only provide <0.6% of food globally thus are negligible compared to crop production).

Another UN CBD study resulting in the 2010 Report (http://gbo3.cbd.int/) called for urgent reduction of biodiversity loss, including efforts to prevent nutrient pollution, reduce pathways for alien invasive species, and introduction of more sustainable practices in fisheries (again!), forestry and agriculture. Hence my justifiable contention that Ecology is far more important and 'valuable' than Economy which is entirely subservient and subordinate. (And then there is the old quip about laying all the Economists in the world head to toe in order to see if they would ever come to a conclusion?!]. As proof of this contention, consider the Moon that has zero Economy because it has zero Ecology...

An updated 2017 review [Ref.] estimates the value of 'free' ecological services with a median value of US$135 trillion per year that is almost double the global economic GDP of around $75 trillion. Thus Ecology appears inarguably more important than Economy. Ecological losses from land use changes (mainly due to industrial-chemical agriculture) [Ref.] are now estimated at around $4 trillion per year which is about double the global combined Agriculture, Forestry and Fisheries contribution of $1.9 trillion [Ref.]

Back down to Earth… worms are ubiquitous in soils capable of supporting higher plants. They are found only in refugia in arid and frozen regions, but in most other terrestrial ecosystems they dominate soil macrofaunal communities with densities and biomass bulk as high as one million per hectare and 2 tonnes per hectare. Because they play a vital rôle in the formation and maintenance of fertile soil, earthworms are of paramount importance to primary production (Fig. 0.0):-

1 - No worms 2 - 4 *P. corethrurus* added 3 months before

A - Two *Sorghum bicolor* 2 weeks before B - Cane trash litter C - Sandy-clay-loam D - Krasnozem

Courtesy of Dr Les Robertson BSES Tully, Qld Australia

Fig. 0.0. Soil effects & plant (*Sorghum bicolor*) growth in two weeks without (lhs) or with earthworms (rhs + four *Pontoscolex corethrurus*) introduced ca. 12 wks before.

The figure above is courtesy of Dr Les Robertson of BSES Tully, Qld, reproduced and distributed with his kind permission. Here are the full details regarding this image from his letter to me dated 24/2/1998:

"*Dear Rob,*

...You may be interested in the photo. The only treatment difference was 4 Pontoscolex corethrurus added to the box on the right. Two sorghum seeds were planted 3 months after the worm introduction [photographed two weeks later]. The soils were taken from sugarcane fields, a Tully-Coom series sandy clay loam and a krasnozem.

I hope to do a little more work on the impact of P. corethrurus on sugarcane trash decomposition and nutrient recycling. Depends on funding, of course!

All the very best wishes – keep in touch. *Les* [Robertson]."

Studies with similar set ups were conducted by Grant (1956: 650, figs. 1-4).

Neither ants, mites, nematodes, nor springtails, etc. whether singly by themselves or combined together could modify soil as earthworms do, nor so positively and significantly influence plant growth. The photo above demonstrates and elequently explains why I, and those with a similar vision/passion over the ages, have concentrated our study efforts on the humble earthworm...

Gilbert White of Selborne was perhaps one of the first to study their ecology when in 1777 he explained: "*Earthworms, though in appearance a small and despicable link in the chain of nature, yet, if lost, would make a lamentable chasm. Worms seem to be the great promoters of vegetation, which would proceed but lamely without them*." [This full citation is given in the Appendix].

The way earthworms modify their soil environment and co-evolve with microbes and plants enhances their own survival, yet it also benefits all other terrestrial life, including ourselves, that for continuation depends on the growth of plants. Nevertheless lowly worms became neglected or even seen a pests until Charles Darwin's works (1838; 1840 and especially his "*Worms and Vegetable Mold*" in 1881) provided a foundation for both Ecology – as yet an unnamed discipline – for Invertebrate Ethology and for the whole of Soil Science. Thus was Darwin one of the first scientists to give credence to the conventional wisdom from earlier civilizations about the beneficial effects of earthworms on soils and plant growth, and therefore on

human survival. His contributions also extended into the realms of anthropology and archaeology, e.g. an experiment Darwin started in 1841 was re-investigated by Keith (1942) and Jewell (1958) – see also Hart & Terrell (2002). Darwin (1881) stated:

> "*It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures...*" and "*The vegetable mould* [humus] *which covers, as with a mantle, the surface of the land, has all passed many times through their bodies*."

Reading Darwin's book inspired many (Ref.); it spurred Dr G.S. Oliver in the USA culminating in his three volume publication "*Friend Earthworm - Practical Application of a Lifetime Study of Habits of the Most Important Animal in the World*" (1941) that concluded with Oliver's autobiographical note:

"*My grandfather's earthworm farm furnishes an example of the technique for utilizing the earthworm in general farming operations, either on a large or small scale. From my observations as a small boy, supplemented by much friendly and loving instruction from my grandfather on the subject of earthworms, and from more than forty years' experience in my own work, I am fully convinced that the harnessing of the earthworm will be one of the major factors in the eventual salvation of the soil. I know that the soil can be made to produce several times as much as the present average, through the utilization of the earthworm.*"

An introduction to a reprint of Darwin's worm book, Sir Albert Howard (1945) made these astute observations:

"*There is a growing volume of evidence from all over the world that agriculture took the wrong road when artificial manures were introduced to stimulate crop production and when poison sprays became common to check insect and fungous pests. Both these agencies destroy the earthworm and thus deprive the farmer of an important member of his unpaid labour force. There is also a strong case for believing that one of the roots of present-day disease in crops, livestock, and mankind can be traced to an impoverished soil and that these troubles are aggravated by the use of chemical manures.*"

Recent resurgence of interest in earthworms is driven by urgent environmental and economic concerns, particularly the need to understand and utilize their function in sustainable agriculture, horticulture and agroforestry; to appreciate their potential for restoring damaged soils; and to exploit their recycling of organic 'wastes' [Lee (1985); Sims & Gerard (1985, 1999); Edwards & Bohlen (1996)]. Soils are the

largest pool of Organic Carbon in the Biosphere with the entire amount of atmospheric C entirely recycled thourgh the soil in about 12-20 years – all normally being processed via earthworms' guts and thus the potential of earthworms to improve food security and sequestration in soils of Carbon to redress global warming associated with the atmospheric greenhouse gas, carbon dioxide, gives further currency (Wallace, 1994a, b; Lal, 2004; 2006: 1710; Ref., 2007; Yu *et al* .2007). One of the first steps to this understanding of natural processes is to reliably identify which species are involved, to determine their ecological functions, and to plot their regional distributions (Blakemore, 1999; 2002).

Arthur Wallace (1919-1989), in a series of insightful papers (Wallace *et al*., 1994), commented on many aspects natural soil fertility and global warming remedies (but he also advocated artificial synthetic polymer soil-conditioners developed by Monsanto which are very poor substitutes for properly structured worm-worked soil).

The importance of earthworms to the survival of terrestrial life relates to their intimate relationship with pedogenesis, the formation of soil, and the effect this has via recycling of nutrients and the maintenance of soil fertility and soil structure on plant productivity. Dr Bill Mollison, co-founder of Permaculture, points out that by sliding through their tunnels, earthworms "*act as an innumerable army of pistons pumping air in and out of the soils on a 24 hour cycle (more rapidly at night)*" (Mollison, 1988). Costing such benefits, David Pimental, an entomology professor at Cornell Uni., conservatively estimates the contribution to agricultural topsoil formation of soil biota such as earthworms and other invertebrates that can bring to the surface from 10 to 500 tonnes/per hectare/per year of soil and thus play a critical role in the formation of topsoil at US$25-50 billion each year; and the minimum benefit of natural decomposer recycling at more than US$760 billion per year worldwide (see Pimental *et al*., 1997). Moreover, a report on biodiversity published by the Irish Government in May 2008 estimated the activities of the earthworm to be worth a minimum of €723 millon per annum to agriculture in Ireland alone. In the UNEP/EU **The Economics of Ecosystems and Biodiversity** accounting scheme called TEEB http://www.teebweb.org/ provides some case studies; with fuller information of costed benefits of environmental services on FAO/AGL website (www.fao.org/ag/AGL/agll/soilbiod/consetxt.stm).

Worms are a key link in the food chains that sustain most ecosystems. Exploitation of this trait through their use as bait, although relatively trivial overall, is

well known from ancient times. For instance, the Maori also utilized the luminescence of native New Zealand earthworm species as fish lures [Springett *et al.* (1998: 88) quoting Miller (1952)]. The fishing bait market based on the 'nightcrawler' in North America was worth more than US$50 million per annum in the 1980's (Tomlin, 1983; see also Collicutt, 2002).

Terrestrial Annelids are also of particular phylogenetic and biogeographical interest since they are an ancient group with generally feeble powers of travel and are thus mostly confined to their areas of origin. Earthworm mobility is usually restricted to small areas at all stages of their life cycle, and most are unable to survive desiccation nor exposure to sunlight or salt water. Exceptions are for those few species that are euryhaline (salt tolerant), and those presumed to have natural assistance via mechanisms such as rafting or floating downstream, and transportation in mud on the feet of birds or on the hooves of animals. Humans have been implicated in wider redistribution of species only in recent times (e.g. stowaways or carriage of cocoons encased in mud in tread of boots, caterpillar tracks or tyres). Examples of euryhaline species are found in *Diachaeta*, *Eukerria*, *Microscolex*, *Dichogaster*, *Pontodrilus* and probably *Pontoscolex*, and some of these may have had their ranges extended by transportation. Since earthworms are soft-bodied, their fossil record is scant (apart from some evidence of Precambrian precursors, a few fossilized samples of cocoons, and 'trace fossils' of their burrows – as mentioned in a later section), yet many current species in some 'primitive' families are akin to 'living-fossils'. Their distributions reflect and are interpreted in terms of past palaeogeographic events whereby earthworms have been passengers passively drifting as the continents have shifted, through geological time, to bring them to their present-day locations. Theories of plate tectonics and continental drift have sought further validation from extrapolating past distribution of the various earthworm families.

In relatively recent times a few species have become particularly widespread mainly because of unintentional transportation following in the tracks of human peregrinations, particularly involving agriculture and commerce. The term **peregrine** – meaning wanderer or wandering, was first used by Michaelsen (1903) to describe the distribution of earthworms that are dispersed over a wide range and in geographically remote localities. Other interchangeable terms are **anthropochorous** meaning transported by man, and **allochthonous** meaning exogenous, originating outside of a particular area. **Cosmopolitan** often has a less precise definition meaning

either found everywhere, occurring in many parts of the world, or merely present in more than one country (Gates, 1972: 63), but ecologically it often implies passive or unitentional transportation. In the Pacific, Lee (1981; 1985) distinguished "*coral island taxa*":- believed to be dispersed by pre-Columbian voyagers, from "*tropical tramps*":- the species probably introduced after Europeans entered this region. The peregrine or cosmopolitan species then, are those that are exotic and widespread. Of a total of ca. 10,000 named terrestrial and aquatic oligochaete worms, at least 5,900 are 'true' earthworms (cf. ca. 3,700 microdriles) and only about 130-150 of these species are widely distributed and commonly encountered throughout the world. Naturally their attendant parasites, pathogens and symbionts accompany them in their travels.

The present account of peregrine species is compiled from extensive surveys of the literature, for example: Michaelsen (1900; 1903), Gates (1942; 1972: 11-16, 62-63; 1982), Sims (1980: 117), Lee (1985; 1987b), from numerous other sources (as acknowledged in the text), and from the author's continuing independent studies. Out of a total of some 940 or so valid species of oriental pheretimoids in the family Megascolecidae (Sims & Easton, 1972; Sims, 1983; Blakemore, 2004, 2005, 2006, 2007, 2010) about 65 species are peregrine. Of the ca. 670 known Holarctic Lumbricidae (Easton, 1983; Blakemore 2004, 2005, 2007, 2010) about 33-35 can be regarded as peregrines. The ranks of another half-a-dozen families provide the balance of the 50 or so species (including another half-dozen or so non-pheretimoid megascolecids) to give an approximate total of 150 peregrine species.

Several earlier accounts of exotic species have tended to over-emphasize the importance only of the lumbricids (family Lumbricidae), to the detriment of other groups, partly because they are so ubiquitous, but probably mostly because they are historically more familiar and easier to identify to workers in Europe and North America/Australia. To graphically demonstrated an overemphasis given to Lumbricdae in the past compared their true status relative to other currently realized species groups, I have charted % abundances here: (Chart 1). Note that only in the impoverished British Isles do Lumbridicae come close to assuming >50% of total taxa.

This ***Guide*** describes the 150 or so most common peregrine species and, where possible, representative specimens are illustrated showing their key anatomical features. Included are those species that are most often used in vermiculture and vermicomposting operations around the world, specifically: the *Eisenia fetida* species-complex; *Perionyx excavatus*; *Eudrilus eugeniae*; *Lampito mauritii*; *Dendrobaena hortensis* and *De. veneta*;

plus several members of the pheretimoid *Pheretima* and dichogastrid *Dichogaster* groups of genera.

Other species supposedly identified (by Patnaik *et al.*, 2004; Anon.) as suitable for vermiculture in India (Orissa), in addition to *Lampito mauritii* (Kinberg, 1867), are: *Drawida calebi* Gates, 1945 and *Dawida willsi* Michaelsen, 1907, *Pellogaster bengalensis* (Michaelsen, 1910: 96), *Octochaetona surensis* Michaelsen, 1910 and *Ramiella sundargarhensis* Julka, 1978: 190. Such groups will also be included where they are known to also have peregrine or cosmopolitan species (rather than natives).

The smaller, ineffectual, and mainly aquatic microdriles that may also occur in humus are not considered here, rather the concern is with the megadriles or 'true earthworms' most of which are terrestrial although some live in water or mud, a few are found on the shores of oceans and others are arboreal (inhabiting trees). The peregrine species are those with distributions far from their regions of origin. Often such species have been recognized in foreign locations before being found in their homelands, although several are now so widespread that they have yet to be reconciled with their exact origins. The transportation and translocation of these earthworms often trace the movement and commerce of humanity, in both historical and pre-historical times. So when we dig our local soils today we can find a rich and diverse community of earthworms that have originated from many different regions of the Globe.

The usefulness of this ***Guide*** (something I wished for when I started this type of ecological work) is in enabling fieldworkers to identify the common exotics in their area – all groups and not just the easy lumbricids – and to give starting references for those species that are either uncommon or are native, whether new or known. For, once the exotics are clearly identified, then further studies can concentrate on regional biogeography and the ecology of species endemic to an area. This process may also assist in reducing the plethora of names that have been precipitously given to the same species by regional authors thinking they have discovered a new and unusual form.

Characters and origins of peregrine species

Most peregrine species tend have some or all of these characteristics: small size; parthenogenicity or asexual reproduction such that just a single specimen may start a colony (Gates, 1972: 16; Sims & Gerard, 1985, 1999: 32; Terhivo & Saura, 2006), often accompanied by polyploidy; high fecundity; resistant cocoons; wide environmental or feeding tolerances (i.e., eurytopic or eurytopicity); and rapid rates of spread (Lee 1985,

1987; Perel, 1987; Blakemore 2002). Gates (1968: 260) commented that parthenogenesis, as often seen in pheretimoids, permits more rapid accumulation of mutations than if reproduction had remained amphimictic and Gates (1972: 19) further observed that parthenogenetic morphs seem to withstand higher parasitic burdens, possibly because less body resources are allocated to reproduction (as their reproductive organs, though perhaps not their reproductive behaviours, are often atrophied). These adaptations may have initially served to exploit virgin soils or organic accumulations that are free from competition resulting from alluvial action, glaciation, vulcanism, or weathering, and are just as advantageous for colonization and survival in soils subjected to agricultural cultivation or in the concentrations of organic matter that accumulates around farms and homesteads. In many sites today, intermixing (but not interbreeding) with the natives endemic to a particular area may be found exotic American ocnerodrilids and microscolecids, Asian pheretimoids, African octochaetids, Indian perionyxes (perionyices?), Neotropical glossoscolecids, Laurasian lumbricids, and even a few Australiasian acanthodrilids and megascolecids. The origins of these species often correspond to Vavilov's eight Centres of Origin of cultivated plants (Vavilov, 1951). The dissemination and occupation of fertile soils by the peregrines from these areas may reflect advantageous symbioses of earthworms with agriculture since earliest times. These associations also mirror the rich infusions of arts and ideas that have rippled out from the various centres of crop origin and of human cultures. From the first domestication of stock and seeds in the Neolithic age, through cultivation of wheat and oats from Asia-minor, farmers of corn and potato in the Americas, rice growers in Asia, the cultivators of millet in Africa and sweet potatoes in New Guinea, we get not just the produce but also a link via the soil fauna to our own diverse cultural origins and global peregrinations. The thesis is that recolonization of Pleistocene glaciated areas of northern Eurasia by earthworms was mainly due to spread with Neolithic Agriculture, since equivalent areas of North America, where cultivation farming with domestication of pack animals did not occur, often lack this soil component.

Once introduced the cosmopolitan species may acquire new territory in soils for some reason temporarily or chronically devoid or yet occupied by populations of endemics. In such cases interactive competition between species is likely. The outcomes vary, and from personal experiences I have often seen varied mixes of intermingled natives and exotics. Possible outcomes are reorted and discussed by Lee (1959, 1985) and Gates (1967: 170) whereby exotics replace or at least "*take the place*

of" natives to varying degrees as much as they may co-exist in such mutual encounters.

A starting point for the current work was the multitude of species located during the author's Australian studies (e.g. Blakemore, 1994; 1996; 1999; 2000; 2001; 2002; 2004, etc.) that, despite modest resources, resulted in a doubling of known exotic species, and addition of ca. 250 new native taxa too to up current total to 715 species. Compare this to those simultaneously reported in a rather 'half-Baked" CSIRO "*Earthworm Identifier*" by non-taxonomists published in 1997 following a "*National Survey of the Earthworm Fauna of Urban and Agricultural Soils in Australia*" to just 27-28 species! [Many of these latter were also misidentified!!]. Surrounded by wide oceans and furthest from traditional trade routes in the northern hemisphere, Australasia was one of the last bioregions to be colonized by Europeans, and thus the exotics found there are likely to be those most liable to transportation and most successful in colonization. Until recent times the continent was largely free from international commerce and cultivation of the landscape. Similarly to other continents, Australia also offers a wide range of habitats and climates – from coastal to alpine, wetland to desert, tropical to sub-Antarctic. The exotic earthworms there are those hardy and tolerant species that can survive the voyage, establish themselves in a variety of soil conditions, and endure – models of peregrine species. They come from all parts of the World and include representative of all the major earthworm families. However it is not all a 'one-way trade' as some Australian natives are beginning to establish a foothold overseas, as noted next:...

Translocation and export of natives and early import of exotics to Australasia

Charles Darwin, influenced in part by his visit on the voyage of HMS *Beagle* in January, 1836 during a hot dry summer, said that until he was informed to the contrary he should scarcely have thought earthworms would be common in New South Wales (Fletcher, 1886a: 523). Yet Australia has a particularly abundant earthworm fauna comprising ~715 species with ca. 650 natives (including 202 from the small island state of Tasmanian) with 10-12 neoendemics and approximately 66 peregrine exotics (Blakemore, 1999; 2000, 2005, 2007, 2012). In comparison, New Zealand now has 228 species (Blakemore, 2012). It is estimated (e.g. Blakemore, 2000) that the Australian total will be several times this number, especially since huge areas such as the Northern Territory and Western Australia have yet to be systematically surveyed: e.g. current NT records are of just 20 spp – about the same number found on a single farm in the south.

Whereas Australia and New Zealand, due to their remoteness and isolation from major world trade except in the last 200 years of recorded history, provide useful information on the capability and rates of spread of exotic species. To a lesser extent than exotics have been imported, some Australian natives have become established overseas, while others have been translocated within the country by human activity. An intriguing instance of deliberate exportation was in 1975 when Dr E. Gordon Hallsworth, then Chief of CSIRO Division of Soils, Adelaide, took native earthworms from Mt Kosciuszko to Strathclyde in Scotland in an attempt to reduce the peat turf mats there (Dr K.E. Lee, pers. comm.; see also Costin *et al.*, 1952). The species involved were possibly: *Cryptodrilus fastigatus* Fletcher, 1889, *Vesiculodrilus frenchi* (Spencer, 1892), *Notoscolex montiskosciuskoi* and *Anisochaeta minor* according to Sims & Gerard (1985), and at least one of these species survived relocation and persists in Scotland. [Note: the species identified by Sims & Gerard (1985, 1999: 136, fig. 49) as "*Spenceriella minor* (Spencer, 1900)" appears to me closer to *Anisochaeta celmisiae* or some other species having three rather than two pairs of spermathecae as Sims & Gerard's (1985: fig. 49) has indication of erasure of a third pair of spermathecal pores in intersegment 6/7]. Other known instances of transportation of Australian natives are *Anisochaeta tenax* (Fletcher, 1886) from around Sydney being reported (as *Perichaeta albida* Michaelsen, 1892) from Marquesas de Mendoza in the South Pacific (Michaelsen, 1900: 226), and *Anisochaeta laingii* (Benham, 1903) from Norfolk Island that has been recorded from Hamilton, New Zealand (Gates, 1965; Blakemore, 1997b, 2012) and from Raoul but possiby misidentified there. Recently, I found *Anisochaeta macleayi* (Fletcher, 1889) in New Zealand along with two congeners: *Anisochaeta kiwi kiwi* and *A. kiwi mihi* Blakemore, 2012 that had apparently yet to be named in their Australian homeland (Blakemore, 2012) and, from a report by Chinn (2011) may also have been introduced to the Kermadecs (reported as *Megagascolidae laingii* (sic) (= *Anisochaeta* and DNA samples agree with *A. kiwi*).

However, the record in NZ of the distinctive 'Blue Squirter Worm', *Didymogaster sylvatica* Fletcher, 1887: 554 which is endemic to Illawarra region NSW, is doubtfully retained as it has never been re-confirmed from New Zealand. The original NZ record according to Lee (1959: 261) was from Ude (1893) quoting a letter from Rosa that Stephenson (1930) thought, as did Lee, was an error of locality. Note: correct authography is *Didymogaster sylvatica* Fletcher, 1887 from ICZN

(1999: Art. 30.1.2.) stating genus names ending in *–gaster* are feminine and there was an Erratum to this effect in the preface of the original publication as "*Di. sylvaticus*".

Whereas two *Rhododrilus* species occur in Australia, probably as introductions from New Zealand (Blakemore, 1994, 1999), specimens of NZ *Maoridrilus* reported from Queensland are probably misidentifications: Lee (1962: 178) found that British Museum specimens (BM 1933:2:23:278 slides) labelled "*Maoridrilus* ?, Toowoomba, Queensland, xi.14; J.H.A." were doubtful. Probably it is a misidentified *Heteroporodrilus* species as reviewed by Blakemore (1994; 2000, 2006) and almost certainly collected by J. H. Ashworth who in September, 1914 from same region collected specimens of Stephenson's (1933) *Plutellus ashworthi* and *P. affinis*, both probable junior synonyms of *Heteroporodrilus oxleyensis* and *Fletcherodrilus unicus*. Similarly, the false report of *Argilophilus marmoratus* Eisen, 1893 from northern NSW is probably a misidentification of some *Heteroporodrilus*.

Several species first described from Australia are now known to be exotics, e.g. *Lumbricus novaehollandiae* Kinberg, 1867 from Sydney is probably *Aporrectodea trapezoides* (Dugès, 1828), and *Lumbricus australiensis* Fletcher, 1886 is also part of the *Aporrectodea caliginosa* species-group (A. *trapezoides* or, possibly, *A. longa*); Asiatic *Pheretima darnleiensis* (Fletcher, 1886/7) was on Darnley Island in the Torres Straits, and *Polypheretima brevis* (Rosa, 1898) on Christmas Island (both Australian territories); *Pheretima peregrina* (Fletcher, 1886) from Sydney is a junior synonym of *Amynthas corticis* (Kinberg, 1867); South American *Microscolex dubius* (Fletcher, 1887) was first described from Adelaide; and Queensland's *Urochaeta australiensis* Beddard, 1891 and *Pheretima enchytraeoides* Michaelsen, 1916 are junior synonyms of *Pontoscolex corethrurus* and *Amynthas minimus*, respectively. Conversely, the euryhaline *Pontodrilus litoralis* (Grube, 1855) that occurs on coastlines around the world is possibly endemic to Australia (Gates, 1972; Blakemore, 1999; 2000; 2007), although the mechanisms by which this species has spread remain largely unresolved.

Imported exotic composting earthworms are routinely distributed around Australia, e.g. *Eudrilus eugeniae* was traced to a worm-grower in Qld (Blakemore, 1994; 1999), but a few native 'vermicomposters' are also used. For example, *Anisochaeta buckerfieldi* (Blakemore, 1997), *A. tenax* (Fletcher, 1886) and *A. dorsalis* (Fletcher, 1887). This latter species, endemic to Vict. and SA, along with the mainland species *Anisochaeta sebastiana* (Blakemore, 1997), have both been recorded from Tasmania (Blakemore, 2000a; 2000b; 2000e). These are the first two

(plus one unconfirmed) translocated mainland natives yet known in Tasmania, but other native species used as fishing bait are routinely transported. For example, native "*Scrub Worms*" from Tasmania are sent around Australia (e.g. to baitshops in Canberra), and those sold in the central montane Great Lakes region of Tasmania come from St. Helens in the coastal north-east (pers. obs.). It is highly likely that these bait worms would be deposited in new locations, but thus far reports of survivors from such events are unknown. Farmers and gardeners also distribute earthworms informally (e.g. see Blakemore, 2000c), but particular species will fail to establish under soil conditions to which they are unadapted.

Soil in ships' ballast, or attached to machinery (especially during WW II), or in rootstock of exported Australian natives, e.g. *Eucalyptus*., *Melaleuca*, or *Banksia* spp, may all have dispersed any resident worms or their cocoons.

2. BIOLOGY AND ECOLOGY

In *The Origin of Species* Charles Darwin (1859), as an ecologist, wrote:

"*It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us.*"

Here I contemplate the worm. Accounts of oligochaete biology, morphology, or terminology are found in Benham (1890 – historically interesting but a bit outdated), Stephenson (1930 – still valid), Lee (1959a, b), Gates (1972 – voluminous but taxonomy often off-track), Sims & Easton (1972), Julka (1988), Lee (1985), Sims & Gerard (1985, 1999 – correct, mostly), Edwards & Bohlen (1996, basics taxonomy now completely useless), or Csuzdi & Zicsi (2003 for just Lumbricidae). An elementary account of earthworms, but with several superceded names, is found online here (partially ex Wikipedia) [Dec., 2008]. However, it may be useful now to provide an introduction to the subject for the benefit of students/ecologists intending to enter this field of study, and for the practical application of findings from agro-ecological field studies, whether conducted in Australasia or elsewhere in the World.

Origins

Earthworms are amongst the most ancient of terrestrial animal groups, their ancestors possibly emerging in the late Precambrian some 650-570 Ma (mega-annum = a million years) ago (e.g. Valentine, 1980; Bouché, 1983: 434, table 38.2; Lee, 1985: 3). Indeed, the lower boundary of the Cambrian ca. 543 Ma is now defined by the common occurrence of horizontal worm-like burrow trace fossils (see Ref1; Ref2), and even earlier dates in the Proterozoic 1 billion years ago have been proposed by Seilacher *et al.*, (1998). Lee (1985: 3) cites reports by Glaessner *et al*. (1969) of marine annelid fossils in South Australian Precambrian sediments (e.g. the Ediacara Hills Assemblages that now date the Ediacaran period extending back as far as 635 Ma), and segmented worms have also been identified from basal Cambrian (542-488 Ma) strata in China and Siberia (Bengston & Zhao, 1997), and from the upper Ordovician (488-444 Ma) and upper Silurian (444-416 Ma) periods in USA and UK (Bather, 1920; Edwards & Lofty, 1977: 38) – see also Ref. Rather than marine origin as assumed, Purschke (1999) refers to a terrestrial origin for the Oligochaeta and secondary adaptation to the oceans.

Great antiquity is also shown by possible earthworm ancestor contemporaries such as the genus *Protoscolex* Ulrich, 1878 (syn. *Pronaidites* Kusta, 1888 for *P. carbonarius*) that was originally defined with:

> "*Body ranging from a medium to a great length, of nearly uniform width throughout its length; body divided transverely by more or less narrow, simple or papillated segments. Anterior and posterior ends obtusely pointed, and, probably because the specimens are fossil, are not distinguishable from each other. No setae or appendages of any kind*."

Ulrich (1879) described four Kentucky fossil species with generotype *P. covingtonensis.* A few others were added, notably *Protoscolex latus* Bather, 1920 from the Upper Silurian period (423-419 Myr) from Herefordshire in Lower Ludlow Beds (cf. ca. 500 million years ago when this region of Midlands England was slowly moving north from around the South Pole). This can be compared to the 495 Myr-old type species of the possibly more complex fossil worm *Palaeoscolex*, i.e. *Palaeoscolex piscatorum* Whittard, 1953 from the Wrekin district of Shropshire.

Suspected time or origin of the earthworm predecessors continues to be forced further back into the past: Michaelsen's (1908) opinion initially was that earthworms arose not later than the Upper Triassic (199-228 Ma) but later Michaelsen (1922) though 'real' earthworms appeared in the Carboniferous (359-299 Ma). Fossil embryos and cocoons were found in Recent and Mesozoic (250-65 Ma) layers (Schwert, 1979; Piearce *et al.*, 1990; 1992; Manum & Bose, 1991), and Late Tertiary (65-3 Ma) and Quaternary (<3 Ma) beds yielded the calciferous glands of *L. terristris* that were previously named as *Arion kinkeli* and *A. hochheimensis* fossils (Gates, 1972: 123). Trace fossils of worm burrows or casts are known, e.g. Grinshill Shropshire sandstone (this quarried stone was use for the lintels of No. 10 Downing St.) that also bares remains of reptilian tetrapods, has trace fossils of worm casts and "*a meandering 'worm' trail about 15 mm wide*" (Benton *et al.*, 1997: 135) from the Triassic [ca. 220M yr ago that preceded the Jurassic age of dinosaurs] (http://www.darwincountry.org/category.php3?trail=2997; and figure). Obviously these origins of these worms are older than the more complex insects. [Incidentally Grinshill village is where I grew up – and where Darwin collected specimens in his youth although he seemingly used the archaic spelling of "Grindshill" – Ref.].

'Bioneers' in the colonization and preparation of the land, these ancestral forms pre-date the invasion by fungi, land plants, insects (ca. 400-500 Ma), dinosaurs and

mammals (ca. 200 Ma), and occur well before the descendents of these early worms – the hominids – arose (ca. 4Ma) (Launer, 2006; Ref.). Earthworms now are ubiquitous in all but the driest of regions and the present-day world distribution of the 20 families have been explained in terms of Wegener's hypothesis of continental drift (Michaelsen, 1922; Lee, 1985; 1994; Sims, 1980). Alfred L. Wegener (1880-1930) formulated his ideas in 1911 and he published them in 1915 after recovering in a military hospital from injuries sustained on the Western Front in the Great War of 1914-1918. It has been suggested by some (e.g. James, 2004: 53) that Michaelsen, who in 1933 named a genus after Wegener, may have been an office neighbor and shared ideas on earthworm world distributions with Wegener which may account for Michaelsen's early considerations of the theory to explain global distribution or earthworms (e.g., Michaelsen, 1903, 1922, cf. 1908).

Recent thories based mainly on magnetic and geologic evidence have linked a conjoined Australia and Antarctica with a proto-North American West Coast as part of a supercontinent called Rodinia (from Russian *родина*, or 'motherland') that began to rift apart no later than 750 million years ago before reforming in different configurations as Pannotia and later as Pangea (also spelt Pangaea – a name developed by Wegener).

Ancestral earthworms are supposedly furnished with an octogonadal battery comprising four testes, a pair each in 10 and 11, and four ovaries, a pair each in 12 and 13 (Gates, 1982: 29). African *A. mutivesiculatus* and American *L. multivesiculatus* have nine pairs of testes in 10-18, and ten pairs of testes in 12-21, respectively.

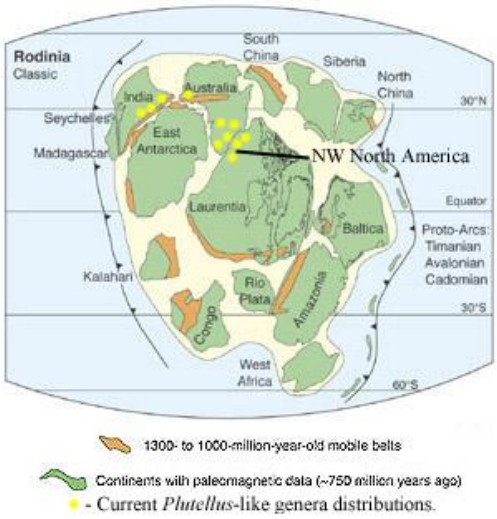


Fig. 1: A conventional reconstruction of Rodinia at 750 Ma (after Torsvik 2003).

[Fig. modified with permission. See also mov].

Earthworm biology, morphology and reproduction

The biological Cycle-of-Life is reproduction, survival, dispersal, and ultimately the death of individuals and the extinction or replacement of species.

The basic morphology of an earthworm is a tube, the digestive system, within a tube, the muscular body. The body wall consists of a diaphanous yet resilient cuticle, an epidermis, muscular layers, and a peritoneal lining. The space between these two tubes is the body cavity, the **coelom**, compartmentalized and filled with fluid that acts as a hydrostatic skeleton. Free floating cells within the coelom perform various functions and are called **coelomocytes**. The body is annular, formed of segments (technically called **somites** or **metameres**) that are most specialized in the anterior, divided internally by the **septa** (singular, septum) that correspond to the external furrows. Intestinal segments are iterations without much modification towards the tail.

The question of segment numbers in adult worms was raised by Gates (1949).

Due to the earthworm's subterranean habitat and its need to build and maintain burrows, there are rarely external appendages and only subtle variations in superficial form prevail. Eye spots and jaws are absent. Apart from their variations in size, body shape, and position of external pores and markings, most worms look alike. In order to identify them, it is therefore essential in most cases to perform some degree of dissection of specimens so that the nature of their internal organization can be revealed. Some patience and skill is required, but it is only through practice that earthworms can be differentiated by relating their internal anatomy to consistent external features. Genomic studies too ***must*** relate to morphological species (types).

Earthworms are hermaphrodite, thus issues of **Sexual Selection** do not apply.

Earthworms are promiscuous, polygamous, hermaphrodites (i.e., with both male and female organs). Their reproductive strategy involves mate location and recognition, mutual exchange of sperm, and the shedding of eggs within a protective and/or nutritive **cocoon** formed at the clitellum (Fig. 0.1). Although there are variations within some groups, particularly where spermatophores are exchanged or there is direct fertilization of eggs, mating, or **amphimixis**, is most often by two individuals going "head-to-tail" with the male pores of one lining up, successively, with the spermathecal pores of another. Sperm from the concopulant is stored in the spermathecae. The **clitellum** is a girdle-like thickening of the epidermis in the anterior or mid-body which detaches and, as it moves forwards, receives eggs (from the female pores) that are fertilized by a partner's sperm (from the spermathecae or

from spermatophores) to form embryos within the shed cocoon. Development and hatching of the young worms is without a larval stage and, apart from the positioning of the cocoons, further parental care is not known. Some species, particularly the most successful peregrines, have parthenogenic morphs that produce viable offspring without mating, but often retain most of their reproductive anatomy or at least the rudiments, and can ideally be traced to their ancestral diploid and bi-parental populations from which they have been isolated. Nevertheless parthenogenesis imposes several "*systematist's nightmares*", as has been discussed at length by Gates (1972: 16-19) who said "*Just how many 'species' were erected on individuals of more of less degraded morphs has not been determined, but the number certainly is greater than several*."

Definition of 'species'

A species is the fundamental unit of evolution, ecology and of taxonomic classification that can be defined as a member of a population or the population itself (i.e., a group of similar individuals living together and separated ecologically or behaviourally from other such groups) which actually or potentially interbreed to produce viable, fertile offspring (after Mayr, 1969; Sims, 1983: 472 and common knowledge). Mayr's (1942: 120) definition of this dynamic was that: "*Species are gruops of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups*". This definition allows that parthenogenetic morphs may yet have sexually reproducing forms thus they may 'potentially' interbreed and, if so, produce viable offspring. [Gates' parthenogenetic morph classifications are given later].

Hybridization

Despite some claims to the contrary, especially for *Eisenia fetida* cultivated by commercial wormgrowers, Gates (1972: 103,107,117) stated that successful experimental interspecific hybridizations are unknown for earthworms. The only exceptions are an unconfirmed report of *Lumbricus rubellus* X *L. festivus* producing hybrid hatchings and, although this was doubted by Gates (1972: 115,117), he thought that because *L. castaneus* and *L. rubellus* are so close anatomically, they might even be more easily hybridized than this earlier claimed *L. rubellus*/*festivus* cross. Laboratory crossed pink (dominant) and green phases of *Allolobophora chlorotica* produced

heterozygous pink F1 offspring that were sterile (Sims & Gerard, 1985: 52); and, according to Gates (1972: 103, 118), there is a report of banded forms of *Eisenia fetida* being cross-bred with unicolored French worms (these F1 hybrids were sterile), and another experiment where ovaries from *L. rubellus* were surgically implanted into *Aporrectodea caliginosa* to obtain supposedly intergeneric hybrids that did not survive to maturity. Recent reports of molecular, or "*cryptic*" species, are discussed later. Any names given to hybrids are invalid and outside of the code (ICZN, 1999: Art. 23.8).

Biometry: Size range

Many peregrine species are small with size of 10 or 20 mm length and ~1 mm width in adults, e.g. several *Drawida* spp., *Microscolex* spp., *Ocnerodrilus occidentalis*, *Dichogaster* spp., pheretimoids such as *Amynthas minumus* and lumbricids such as *Dendrobaena pygmaea*; the cocoons of such species are also proportionately small which probably facilitates their dispersal. Some endemic litter dwelling or arboreal species are also in the range 10-20 mm in length and about 1-2 mm diameter (e.g. see Lee, 1959; 1981; 1985). For example, *Metapheretima agathis* and *M. buckerfieldi* both by Lee (1981) from Vanuatu, measure less than 17 mm, and *Amynthas infantilis* (Chen, 1938) from Hainan is only 10-24 mm long.

Various earthworm families also have 'giant' members – some ~3 m long, e.g. *Amynthas mekongianus* (Cognetti, 1922) as redescribed by Blakemore *et al.* (2007b). Stephenson (1930: 1) and Blakemore (2002: 13; 2006; *et al.* , 2007b) listed several of these giant worms and often they are endemic sub-soil dwellers that presumably require relatively long life-spans to attain full size. Some are presented next:

Examples of 'giant' or 'gigantic' worms are:

Family Moniligastridae: Japanese *Drawida hattamimizu* Hatai, 1930 extends to 1m (see Blakemore *et al.*, 2010); and *Dr. nilamburensis* (Bourne, 1894) and *Dr. grandis* (Bourne, 1887) from India may be as much as 760 and 1,080 mm, respectively, the latter species burrows to depths of 3m (Julka, 1988: 33). Sumatran *Hastirogaster houtenii* (Horst, 1897: 97), previously in genera *Moniligaster* or *Eupolygaster*, has a size up to 1,500 mm (Gates, 1972: 243); and *Eu. coeruleus* (Horst, 1895: 137) (syn. *M. viridis* Beddard, 1895: 203) from Sarawak, Borneo is ca. 380 by 15 mm with 270 segments.

Type-species of Acanthodrilidae from New Caledonia, *Acanthodrilus ungulatus*

Perrier, 1872, attains 700 mm, but most other members of the family are smaller sized.

Family Octochaetidae: Sims (1986: 274) says that most species of *Millsonia* are large, a few being over 500 mm and several having more than 500 segments. Also *Eutyphoeus gammiei* (Beddard, 1888) in India may reach a size of 405 mm, and the type-species of the family, *Octochaetus multiporus* (Beddard, 1885) in NZ, has a size range 180-300 mm (Lee, 1959: 115).

Exxidae type, *Exus wyensis* Gates, 1959, is (was?) up to 500 mm long.

The type-species of the Family Megascolecidae: *Megascolex caeruleus* Templeton, 1844 from Sri Lanka is over 1m, and *Megascolides australis* McCoy, 1878, the 'Giant Gippsland Earthworm' from southern Victoria, Australia was originally recorded with a size of 1.23m, or a little over 4ft., but specimens with lengths of about 6ft., and even 7ft. 2in. (2.184m) have been measured that weighed 400-450g (Spencer, 1888). It has 300-500 body segments. There are reports of specimens being "stretched" to 12-13ft. (3.7-4m), however, the average size is about 1m according to Dr Beverley Van Praagh of the Museum of Victoria who has studied the biology and conservation of this remarkable worm (Van Praagh, 1992). *Notoscolex grandis* Fletcher, 1886 from Burrawang, NSW measures 760-1,060 mm long by 11 mm wide; it was recently rediscovered near there by the current author (Blakemore, 2001c) (Fig. 0.2); in Victoria, *N. hulmei* (Spencer, 1892) grows to 1,200 mm. Several other Australian natives in the genera *Digaster*, *Heteroporodrilus*, *Fletcherodrilus* and *Diporochaeta* have species in the range 600-1,500 mm (see Blakemore, 1994) (Fig. 0.3; Fig. 0.4), for example, red-coloured *Fletcherodrilus unicus major* (Spencer, 1900) measures around 600 mm in length, while the *Digaster brunneus* Spencer, 1900/ *D. longmani* Boardman, 1932 complex measure up to 1,500 mm. The single representative specimen of *Vesiculodrilus vallis* Blakemore, 2000/6 from Mt Kosciusko is over 200 mm by 15 mm. The largest known species from Tasmania is *Vesiculodrilus tasmanianus* (Fletcher, 1887) which was described at over 610 mm, or about 2ft. long and while this is much shorter than sizes attained by *Megascolides australis*, these two species are of equivalent width, about 25 mm. Specimens of *V. tasmanianus* dug during forest trail building operations were found at about 1-1.5m depth, but some burrows descended to 5m (Blakemore, 2000e).

From India we have *Megascolex konkanensis* Fedarb, 1898 that has sub-species up to 415-570 mm by 3-4 mm. New Zealand's *Anisochaeta gigantea* (Benham, 1906) may measure 990 mm when preserved, but 1,300-1,400 mm when alive and

extended, with a width of 11 mm and ca. 450 segments (Lee, 1959: 340).

North American *Driloleirus americanus* (Smith, 1897) from eastern Washington and *D. macelfreshi* (Smith, 1937) from Oregon grow up to "*3 feet*" (roughly a meter long); these worms may burrow to 5m depth in the Columbia River basin habitat that is considered at environmental risk [palouseprairie.org/invertebrates/palouseworm.html].

From southeast Asia the pheretimoids, *Amynthas mekongianus* (Cognetti, 1922) is found to be 2,900 mm long by 4-8 mm wide with more than 500 segments (Blakemore *et al.* 2007b), and *Polypheretima elongata* (Perrier, 1872) has a usual range of 40-360 mm long but a specimen in the author's Queensland studies reached >450 mm in life (mass 8 g), however both these taxa are relatively slender. *Archipheretima ophiodes* (Michaelsen, 1929) is said to reach to 20 mm diameter and body 300 mm long. A recently described Taiwan species, *Metaphire taiwanensis* Tsai *et al*., 2003/4 is 637-860 mm long by 16-17 mm wide with 185-228 segments and weight of 101-121g. In Myanmar (Burma), the lumbricine *Tonoscolex birmanicus* Gates, 1926 from Pyin U Lwin or Pyin Oo Lwin (formerly Maymyo) is over 600 mm long by 10-15 mm and up to 7ft or 10ft (=2,130 or 3,050mm) long in some reports:– this species builds large tower-like casts that may be 25 cm tall and weigh about 4 pounds (1.8 kg) according to Gates (1972: 227).

Previous maxima for pheretimoids were 700 mm for *Metaphire magna* (Chen, 1938) from Hainan; and the highest segmental counts were 297 for *Po. elongata*, and 200-600 for *Metapheretima jocchana* (Cognetti, 1911) from New Guinea that is up to 600 mm long by 10 mm wide with up to 600 segments and as many as 200 setae per segment, while sympatric *Metapheretima sentanensis* (Cognetti, 1911) has 300 setae per segment (Easton, 1979: 88, 114). Other 'gigantic' earthworms in the pheretimoid group ranging 550-700 mm (Tsai *et al.*, 2004a: 883) are *M. magna* (Chen, 1938) of Hainan, *M. musica* (Horst, 1883) and *M. longa* (Michaelsen, 1892) from Java and Sumatra, and *Amynthas fluvialis* (Gates, 1972) in banks of Mekong in Thailand (now a synonym of *A. mekongianus* – by Blakemore *et al.* 2007b).

Family Microchaetidae in South Africa is a group of sometimes 'gigantic' species all to about 1 m or more long (Plisko, 1999), these are: *Microchaetus microchaetus* (Rapp, 1849) which has a length of 1.80m by 16-18 mm wide with 792 segments (! but see *Kynotus giganteus* below); the recently reinstated *M. rappi* Beddard, 1886; Michaelsen's (1899) *M. braunsi* and *M. decipiens*; and *M. klopperi* and *M. stuckenbergi* both of Plisko (1991). The longest reliable record is *M. vernoni* Plisko,

1992 that in life is ca. 2.6 m long and which excretes large casts up to 240 mm high. Newspaper reports of a South African specimen measuring 7m by 75 mm were thought improbable by Lee (1985: 9).

Madagascan family Kynotidae has *Kynotus longus* Michaelsen 1891 at 800 by 8 mm with 770 segments, *K. feiderici* Michaelsen, 1931 at ca. 1,000 mm or *K. giganteus* Razafindrakoto *et al.*, 2011 at 1,450 mm with 1,330 segment! This latter paper proves how little we yet know, or care, about earthworms on this planet when such large species are overlooked and their discovery generates so little media/scientific interest.

The South American family Glossoscolecidae has 'giants': *Thamnodrilus gigas* (Perrier, 1872: 50), 1,160mm; *Rhinodrilus horsti* (Beddard, 1892: 117), 860 mm and *Rhinodrilus priollii* Righi, 1967 >1m (and possibly >2m); *Glossoscolex paucisetis* Michaelsen, 1900: 445, 673mm; and *Glossoscolex giganteus* (Leuckart, 1835/6: 764) [syns. *G. maximus* Leuckart, 1841: 104, *Titanus brasiliensis* Perrier, 1872: 57, *T. gigas* Perrier, 1881: 218] that measured 1,270 mm by ~15 mm wide, with 550 segments was said by Leuckart to possibly extend up to 8-9 feet (ca. 3m) in life (Beddard, 1895: 644). Stephenson (1930) stated that *Rhinodrilus fafner* Michaelsen, 1917, which measures when extended 2m. in length and 24 mm in diameter, rates with *Megascolides australis* as probably one of the largest of all earthworms (cf. *Amynthas mekongianus* reported herein), it was officially declared extinct by the Brazilian Ministry of Environment (MMA) in 2003 but later found (IOTM, April, 2011). *Martiodrilus* (*Cordilleroscolex*) *beddardi* (Cognetti, 1904), *M.* (*C.*) *crassus* (Rosa, 1895), *M.* (*C.*) *iserni* (Rosa, 1895), *M.* (*C.*) *columbianus* (Michaelsen, 1900), and *M.* (?) *olivaceous* and *M.* (?) *panamensis* both by James (1990) are all about 400-800 mm by 16-25 mm. Other 'giants' are the recently described Ecuadorian *M.* (*C.*) *ischuros* Zicsi, 1990: 370 that exceeds 1m by 40-50 mm in life [cf. *M. crassus* (Rosa, 1895: 151) that also reaches these dimensions - see Zicsi & Csuzdi (1997) Fig. 0.5]; and the Amazonian *Andiorrhinus* (*Andiorrhinus*) *kuru* Moreno & Paoletti, 2004 that has length of 500 mm (living specimens measure up to 1,100-1,300mm) with diameter of 20-30 mm, 342 segments and mass 122.5g for the holotype. This latter species is used as a local food resource in Venezuela (Moreno & Paoletti, 2004, Fig. 0.6 - photo courtesy of M. Paoletti).

The Mediterranean family Hormogastridae has one of the larger European species, *Hormogaster redii gigantea* Michaelsen, 1917 (sometimes misspelt "*gigantes*"), at about 750 mm, while *Ho. pretiosa*, although smaller at 360 mm, has ca.

600 segments.

Family Lumbricidae: *Lumbricus terrestris* Linnaeus, 1758 and *Octodrilus frivaldszkyi* (Örley, 1885) both grow to about 360 mm, *Oc. permagnus* Pop, 1989 reaches 800-900 mm and *Scherotheca* (*Scherotheca*) *gigas* Dugès, 1828 from Montpellier measures ~720 mm. *Eophila tellinii* (Rosa, 1888) is also a large species, up to 800 mm in Italy. Lee (1985) considered the largest of lumbricids (with an original subspecific name that was almost as long but which is now elevated to species status) to be the French *Scherotheca* (*Opothedrilus*) *occidentalis thibauti* Bouché, 1972 that apparently measures ~1,005 by 25 mm and weighs 106 g.

Longevity

It may be reasonably assumed that large species take several seasons to gain size, but data are scant on probable length of life in nature (Lee, 1985). Some 'giant' species may take years to mature and breed only every two or three years e.g. *Megascolides australis* as reported by vanPraagh (1992). Field populations of some species may have only a seasonal life-expectancy, remaining in embryonic dormancy in cocoons during unfavourable conditions. Averages of between 1-2 years are reported for adults of several common species. A maximum life span reported for *Eisenia fetida* was 5 years, however laboratory cultures of *Aporrectodea longa* survived 5-10 years (Gerard, 1964; Gates, 1972: 74, 100), and adult *Lumbricus terrestris* have been maintained for an incredible 30 years (Sims & Gerard, 1985: 22).

Criodrilus lacuum appears a particularly long-lived culture species as it has survived more than 44 years to the end of 2008; Dr Tarmo Timm (pers. comm. Jan, 2009 and in July, 2007) reported: "*I have maintained aquatic oligochaetes in aquaria (Centre for Limnology, Estonian University of Life Sciences, Estonia) for many decades. Among them, an aquatic "earthworm"* Criodrilus lacuum*. A number of the latter were taken from the Daugava River (Latvia) in 1965, and then held in several small aquaria. Most of them survived but did not reproduce in aquaria. The only individual hatched from a cocoon laid in my aquarium, lived 34 years (1968-2002). Many of the individuals caught in the river as adults, spent in aquaria up to five years, and some single individuals considerably more: 6, 11, 12, 13, 14, 16, 17, 18, 22, >23 (several but dried up), and 38 years; the last individual is yet alive when having survived already* ***42 years*** *(1965-2007). Published data on the same batch of* Criodrilus lacuum*: Timm, T. 1984. Potential age of aquatic Oligochaeta. Hydrobiologia* ***115:*** *101-104. [there: at least 17 years*]."

Cryptobiosis and Mimicry

Several *Planapheretima* species that live in trees and on bamboo have cryptic colouration or camouflage. Michaelsen (1930) describes Philippine earthworms mimicking snakes and I have speculated that the bright blue colouration (only in adults) of Japanese *Amynthas sieboldi* and *Didymogaster sylvatica* in Australia and the banding as found in *Amynthas yambaruensis* in Okinawa and *Fletcherodrilus fasciatus* in Australia (and *Eophila tellinii* in Italy?) may serve to distract predators, especially bird. A unidentified caecilian from French Guiana (Tomas Pavlicek, pers. comm. April, 2011) that appears adapted to especially resemble a worm (also unidentified) – including a fake clitellum! – I suspect would be of value only if the particular worm it mimics was poisonous, such as found when some Australian species that Fletcher said smelled of creosote, just as some American worms smell of lilies.

Regeneration

Earthworms have the facility to replace or replicate lost segments, but this varies between species and depends on the extent of the damage and, perhaps, the autotomy ability and predator exposure. Johnston (1865: 320, 322) noted that some earthworms were known to grow a new 'head'. Stephenson (1930) devoted a chapter of his great monograph to this topic and Laverack (1963) provides some additional information. G.E. Gates spent 10 years studying regeneration in a variety of species, but "*because little interest was shown*", Gates (1972) only published a few of his findings that, nevertheless, show it is theoretically possible to grow two whole worms from a bisected specimen in certain species. (Because of this regenerative capacity, the current writer thinks the term 'individual' is not strictly acurate when referring to a specimen that can be 'divided' into two new worms – and on a similar theme the term '***creature***' or even '***critter***' should no longer apply to organisms that were not, after Darwin's work, divinely 'created'). Such regrowth is often in response to mechanical damage from predator attack, trampling, or possibly from garden and field cultivation, but it may also be evoked by disease and autotomy (usually of tail segments but possibly also of heads in response to parasite infestation). Gates (1949) said:

> "*Posterior amputation may occur naturally in all post-embryonic stages of the life history of earthworms. Frequency increases with age, sometimes reaching one hundred per cent. After amputation healing may be enteroparietal or cicatricial. In the latter case subsequent developments may be either progressive or regressive.*

Some species apparently are unable to regenerate posteriorly."

Reports by Gates (1956) [see also Ref.] included:

Eisenia fetida (Savigny, 1826) with head regeneration, in an anterior direction, possible at each intersegmental level back to and including 23/24, while tails were regenerated at any levels behind 20/21; thus a single worm may produce two regenerates. See also Gates (1949).

Lumbricus terrestris Linnaeus, 1758 replacing anterior segments from as far back as 13/14 and 16/17 but tail regeneration was never found for this species.

Dendrodrilus rubidus (Savigny, 1826) with head regeneration from 17/18, but caudal regeneration weak (Gates, 1956).

Perionyx excavatus Perrier, 1872 readily regenerated lost parts of the body, in an anterior direction from as far back as 17/18, and in a posterior direction as far forward as 20/21; thus it too may readily generate two worms from one specimen.

Lampito mauritii (Kinberg, 1867) with regeneration in anterior direction at all levels back to 25/26 and tail regeneration from 30/31; sometimes head regeneration was believed to be caused by internal amputation resulting from "*Sarophaga*" (= *Sarcophaga* sp?) larval infestation.

Ocnerodrilus occidentalis (Ocnerodrilidae) and *Dendrobaena octaedra* (Lumbricidae) also have prodigious regenerations capacities showing that no family has a monopoly on this attribute (Ref.).

Field observations by the author are of both tail and head regenerates of exotic *Perionyx excavatus* Perrier, 1872 (from wormbeds); *Pontoscolex corethrurus* (Müller, 1857) from the field in the process of anterior regeneration; and an active specimen of *Lumbricus rubellus* Hoffmeister, 1843 with this condition (author's collection). Blakemore (2001b) reported an unidentified Tasmanian native that was growing a second head (Fig. 0.7) – notice presence of genital markings (GMs) but regressed clitellum. Recently, a specimen of *Anisochaeta kiwi kiwi* Blakemore, 2012 was recovered from Mt Wellington in Auckand, N.Z. that was also regererating a 'head'; it lacked the GMs of its compatriots so was probably in a non-reproductive state whilst recovering from injury likely caused by predators.

Predators, parasites, pathogens and symbionts

Earthworms are ultimate detritivores: consuming and processing all parts and

products of plants and animals that have lived, and died, on or below the ground. Thus, while earthworms may have many beneficial attributes and immunities, their long evolutionary history and intimate contact with soil has resulted in various parasitic and symbiotic associations, some of which are of concern to human health and to farm quarantine. Caution is thus required when transporting vermicomposting or bait species, and especially unsterilized bedding material, from one area to another.

The perfect embodiment of a prey organism,: earthworms are high in moisture (~70%), which is crucial for the likes of nestling birds, and high in protein (~70% dry weight), amino acids, calcium, iron and vitamins (Ref.). Their autotomy defense mechanism and regeneration capacity means that the worm may survive after capture only losing expendible part of their 'tail'. Importance of earthworms in the food-web is shown by the numerous predators and their being intermediate hosts for many parasites. Examples of predators are humans [e.g. children, native cultures such as the Maori and Ameri-indians – see Eisen (1900: 247), Moreno & Paoletti (2004) – SAS soldiers (Wiseman, 1995)], grizzly bears (Matteson *et al.*, 2002), Malayan sun bear (*Helarctos malayanus*) and pangolin (*Manis javanica*) – see Wong *et al.* (2002), otters, foxes, badgers, pigs, bandicoots, hedgehogs, shrews, otters, moles e.g. eastern American moles (*Scalopus aquaticus*), mice, at least one species of bat, Australian platypuses and echidnas, and many birds [including woodcock (*Philohela minor* Gmelin), kiwis and owls (Haunsome *et al.*, 2004)], tortoises, snakes [e.g. the eastern garter, *Thamnophis sirtalis* Linnaeus, prey extensively on earthworms while Butler's Garter Snake, *Thamnophis butleri* in Ontario has a diet that is 93% earthworms (Reynolds, 1977; Jiang *et al*. 1990); in Mexico and Central America, species such as *Ninia sebae*, the Red Coffee Snake also feed on worms], frogs, toads, salamanders, caecilids (Ref.), fishes, eels, molluscs [e.g. *Testacella* spp. slugs and, in NZ, certain snails – see Murray, 2005], insects [such as *Scolopendra* centipedes, carabid (e.g. *Feronia madida*) and staphylinid beetles], ants (*Dorylus molestus* driver ants' main prey type in Kenya), mites, spiders [many species from 12 spider families reported by Nyffeler *et al.* (2001) and Ross (2008) including the giant South American Goliath Birdeating spider *Theraphosa blondi* that, despite its name, has main diet of earthworms (Ref.)], and their cousins the leeches such as *Trocheta subviridis* in Europe (and Queensland where it decimated a worm farm, RJB pers. obs.) and giant leeches in Borneo, Japan and Chile [e.g. *Mimobdella buettikoferi* Blanchard 1897 predatory on the large Mt Kinabalu earthworms identified by RJB as *Pheretima*

darnleiensis (see Ref.), *Mimobdella japonica* Blanchard 1897, and *Americobdella* spp.]. Considering leech predation on *Criodrilus lacuum*, it was claimed by Örley (1881) that "*amongst the Hirudinea, species of* Aulostoma *and* Nephelis *are their greatest enemies; these swallow three or four Criodrili at a time*" (see also notes below for *Criodrilus bathybates* species associations). In certain circumstances, earthworms are consumed by crabs (Crustacea) (Ref.).

Other renowned invertebrate predators are planarian flatworms [e.g. the peregrine *Australoplana sanguinea alba* (Dendy, 1891) – formerly *Caenoplana alba*, from Australia and Tasmania; *Arthurdendyus triangulatus* (Dendy, 1895) – formerly *Artioposthia triangulata*, from N.Z. and now spread to the UK; *Bipalium kewense* Moseley, 1878 from south-east Asia that is now widespread around the globe; *Bipalium nobile* Kawakatsu & Makino, 1982 that is probably a Chinese native originally described from the Imperial Palace gardens, Tokyo and that measures up to 1m in length, and *Geobia subterranea* (Schultze & Müller, 1857), sometimes mispelt "*G. subterranean*" a natural predator of *Po. corethrusus* in Brazil]. There is even at least one cannibalistic earthworm – *Agastrodrilus dominicae* Lavelle, 1981 (Octochaetidae:Benhamiinae) recorded from West Africa.

Behaviours used by North American wood turtles (*Clemmys* spp.) to invoke and exploit the escape response of earthworms are by stamping their feet on the soil surface (e.g. Kaufmann,1986; Kirkpatrick & Kirkpatrick, 1996), and predatory birds such as herring gulls, lapwings (*Vanellus* spp.) and the Peewit (*Tringa vanellus*, Linn.) also mimic the vibrations by 'paddling' on the soil surface (Darwin, 1881: 28; Sims & Gerard, 1999: 25). New Zealand's flightless kiwi (*Apteryx* spp.) probes the soil and detects prey by smell having nostrils on the end of its long thin beak which it uses like a pair of chopsticks. If a kiwi catches an earthworm, it pulls it out in a series of smooth movements, bit by bit, so that it doesn't break the worm in two. Also in New Zealand's subantarctic isles, feral pigs have earthworms as 26.3% of their diet (Ref.), this is dry weight so actual wet percentage would be higher. Moles are reported to bite off the heads of captured worms to paralyse them for storage in special chambers (Sims & Gerard, 1999: 23, 25), although I conjecture this may also allow time for the worms to empty their guts of unpalatable and abrasive soil. Moles are also reported to squeeze the worms to void their guts of soil before eating them.

Earthworms are the intermediate hosts of certain parasites of higher animals, and have been implicated in the distribution of both pathogenic and beneficial plant microbes.

Parasites include carnivorous flies (e.g. *Pollenia* spp.), helminths, pathogenic nematodes (e.g. *Metastrongylus spp., Choerostrongylus spp*.), fungi (e.g. *Thielovia terricole*), protozoans (Ref1, Ref2) especially the gregarine *Monocystis* spp., bacteria (e.g. *Mycobacterium avium paratuberculosis*) and viruses. Cocoons may be parasitized by nematodes or mites, e.g. *Histiosoma murchiei* Hughes & Jackson, 1958 can cause mortality of hatchlings and, in some countries, 45% of *Allolobophora chlorotica* cocoons are thought to be infested (Gates, 1972: 73). High infection of lumbricid cocoons with this mite were reported by Oliver (1962) in Michigan, U.S.A. Earthworms neutralized anthrax spores (Koch, 1882) but have been found to be carriers of foot-and-mouth disease of cattle and to distribute both pathogenic and symbiotic microbes of plants (see Lee, 1985: 153, 274; Reddell & Spain, 1991). Gates (1972) refers to the parasites of various species, and associations between nematodes and earthworms (in different life stages as phoretic, paratenic, intermediate or as definitive host) were reviewed by Poinar (1978) who listed some 150 spp, only some of which are parasitic to hosts other than earthworms. Edwards & Lofty (1977) and Rysavy (1969) summarised a range of helminth parasites for which earthworms are intermediate hosts. Some species may disperse eggs of members of tapeworm family Taeniide (e.g. *Taenia spp.*) that cause zoonotic infections of humans and domestic stock. Earthworms are also hosts to *Histomonas* sp., a protozoan parasite causing blackhead disease in fowl. Infection of human lungs, kidneys and mesenteries by nematodes apparently derived from earthworms are known (e.g. Ghabbour, 1966).

Dense accumulations of symbiotic bacteria in the excretory organs were described by Knop (1926) in the family Lumbricidae and these nephridial symbionts were assumed to play a role in the degradation of proteins in the excretory fluid for nitrogen recycling (Schramm *et al.*, 2003). An interesting feature, the phagocytosis and intracellular destruction of microorganisms by the nephridial epithelial cells, was described by Villaro et al., (1985). Information on other symbioses between soil mesofauna and microbes is presented in a later section (Effects on Soil Processes- here).

Human accidental worm parasitism reports are in Blakemore *et al.* (2012).

Population abundance and diversity

In *The Origin of Species* Charles Darwin (1859: 58) wrote:

"*Throw up a handful of feathers, and all must fall to the ground according to definite laws; but how simple is this problem compared to the action and reaction of the innumerable plants and animals which have determined, in the course of centuries, the proportional numbers and kinds* [of species]..."

Populations are usually estimated by sampling, handsorting, and counting the number of worms (just the 'heads') per unit area (see "Collection" under later ECO-TAXONOMY section). In some situations, the amount of mole activity, or number of songbirds may give rough estimations of earthworm abundance, as indeed do the number of surface worm casts or verdant plant growth. Adequate sampling requires good ecological methods such as sufficiently large quadrat size and sample numbers, with consideration of depth, season, immatures/cocoons, "edge effects", etc. And good taxonomic skills/guides are needed to identify the community component – this includes thorough search of the Historical Scientific literature to find earlier species records.

Contingency table of biodiversity sampling reliability

Case	Ecological Sampling	Taxonomic treatment	Results
1	+	+	Representative data
2	+	-	Under/over-estimate
3	-	+	Under/over-estimate
4	-	-	Unrepresentative data

+, Good; -, Poor (Most studies are Case 4, or Case 2 at best).

Earthworm communities may comprise four components (Blakemore, 1999): **resident natives** that are often highly endemic (i.e., indigenous and restricted to a certain area); introduced **exotics** that tend to be more widespread; **translocated natives** i.e., endemic species that have been transported (by humans?) within a bioregion; and "**neoendemics**" i.e., those species that have sojourned for sufficient time following introduction to have undergone speciation in a new region (or are currently unknown or extinct in their places of origin) – examples described as possibly neoendemic are *Lumbricus badensis* Michaelsen, 1907 in southern Germany, *Begemius spp*. in northern Australia, several *Microscolex* on Subantarctic Islands, *Dichogaster* spp. in the Pacific, and several '*Pheretima*' species in the Solomons (Gates, 1958: 6).

Many of the common peregrine exotics are known to have parthenogenetic morphs so, in principle, just a single specimen or cocoon is needed for establishment in a new area (Gates, 1972: 16; Sims & Gerard, 1985, 1999: 32).

Lee (1985: tab. 7) summarized abundance and diversity data from regional habitats, nothing that most surveys claimed only two or three species per site (means **273 m^{-2} and 63 gm^{-2}** as in tables presented below). For tropical rainforests, data in summary by Fragoso & Lavelle (1992) had mean 68 m^{-2} with range 3-401 m^{-2}, biomass mean 12.9 g m^{-2} and diversity from 4-14 species per site. They concluded that the values were not very different to those in temperate woods, but they were lower than in temperate and tropical grasslands. Thus the commonly repeated idea that earthworms are replaced by ants and termites in tropics is not supported by this data. [Note population figures were over-reported by a factor of x 10 in a publication by Ruiz et al. (2015: tab. 3) and Pimental & Burgess (2013: 451) have 10,000 earthworms in one cubic metre of soil but this probably relates more to nematode worms that may number up to 50,000 per m^2!].

A population average of 100 earthworms m^{-2} with say average length of 10 cm would give a density of 1 million ha^{-1} and would extend for 100 km ha^{-1} !

Yet higher bio-diversity has been recorded from some sites, for example: from a total of about 40 species identified during three years' observations around Brisbane in Qld., 24 (16 exotic spp.+ 8 native spp.) were located mainly on and immediately adjacent to a ca. 100 ha farm at Samford in south-east Queensland (Blakemore 1994; 1997a); 24 species (5 exotics and 16 natives plus 3 microdriles) were collected one week at Lake Pedder, Tasmanian Wilderness World Heritage Area (Blakemore, 2000, 2010); and ca. fifteen species (10 exotics and 4 natives plus enchytraeids) were found after a couple of days' survey on a 45 ha property at Budderoo in the Southern Highlands of NSW (as listed in Blakemore, 2001c). While the average Australian backyard garden can support a varied community, often of a dozen or more species, both known and new (e.g. Blakemore, 1994; 1997b). A recent survey of a paddock at Mt Wellington in Auckland found seven species in less than an hour, one of them a new lumbricid record for New Zealand and the other a new *Anisochaeta* species from Australia! Two organic farms in Philippines supported 12 and 21 species (Blakemore, 2016a, 2016b).

In Taiwan, a team quadrat survey from coastal plain to summit at 3,200m yielded 34 species consisting of 19 natives and 15 exotics (Tsai *et al.*, 2004b). A survey of Tam Dao National Park, Vietnam in Oct., 2005 of natural and cultivated lands found 38 earthworm spp belonging to 5 genera, 4 families (Huỳnh *et al.* , 2006).

Results of Lake Biwa, Japan surveys by current author (31st January – 2nd February, and 1st – 5th October, 2007 and in 2009-2010) revealed a total of more than two dozen species plus several microdriles (e.g. *Branchiura* sp., ?*Tubifex* spp.) and at

least three species of freshwater leeches around the lake from approximately 30 sample sites (representative specimens fixed in alcohol on Lake Biwa Museum register): **Eco-taxonomic results:** (Species recorded, especially at the Fudogawa site, beside the creek and under *Eucalyptus* gum trees around Lake Biwa in October, 2007 were):

1. *Eukerria saltensis* (Beddard, 1895) OCNERODRILIDAE (exotic) [reasonably abundant around lake, this the 3rd record from Japan - see Blakemore *et al.* (2007); nematodes internally in one specimen sent to Moscow for identification].
2. *Amynthas* and *Metaphire* spp.MEGASCOLECIDAE (native/exotic), numerous.
3. *Criodrilus bathybates* Stephenson, 1917 CRIODRILIDAE in swampy water.
4. *Aporrectodea trapezoides* (Dugès, 1828) LUMBRICIDAE (exotic).
5. *Dendrodrilus rubidus subrubicundus* (Eisen, 1874) LUMBRICIDAE (exotic).
6. *Eisenia japonica* (Michaelsen, 1892) LUMBRICIDAE (?native).
7. Leech (Hirudinea), possibly a worm predator as abundant in same habitat (?native).

There was also evidence (e.g. droppings, footprints, drill holes) of long billed bird probing in the sandy shores for worms/leeches as food at this site (sp. unknown). Thus *Criodrilus bathybates* was shown to persist around the shoreline of the southern basin of Lake Biwako, but it appears less abundant beside polluted waterways and under cultivation (e.g. paddies around Ogoto on west side) and is absent from coarse sandy or gravelly beaches more prevalent for the northern basin. Sharing the same habitat with *Criodrilus* are several native/exotic LUMBRICIDAE (including a specimen of the new native *Helodrilus hachiojii* Blakemore, 2007 found in a paddy at Shiotsuhama, Nishiazai-cho to the north of the Lake – collected by R.J.B. on 4.x.2007, LBM 1380000005), various pheretimoids, and quite often the exotic semi-aquatic *Eukerria saltensis* (Beddard, 1895) that is considered a pest of rice in Australia (Blakemore *et al.*, 2007). The pheretimoids (Megascolecidae e.g. *Amynthas* or *Metaphire* spp.) are more common and diverse in disturbed agricultural fields (or polluted soils) around the lake.

A subsequent survey at Kurotsu, Lake Biwa 17th June, 2009 found *Amynthas megascolidioides* (Goto & Hatai, 1899), *A. tanbode sp. nov.*, *E. saltensis, Drawida* cf. *barwelli/ D.* cf. *japonica, Eisenia japonica, A. gracilis, A. corticis, Metaphire hilgendorfi, A. hupeiensis*, *Dendrodrilus rubidus* subspp. and confirmation of *Helodrilus hachiojii* (i.e., 11 or more species, plus three leeches and many microdriles).

Further, on 18th June, 2009 the large MONILIGASTRIDAE, *Drawida hattamimizu* Hatai, 1930, was collected in rice paddy at Hikone beside Biwa along with *Drawida japonica* (Michaelsen, 1892), *Helodrilus hachiojii* Blakemore, 2007,

Amynthas hupeiensis (Michaelsen, 1895), *Amynthas robustus* (Perrier, 1872) [now identified as *Metaphire ryunome* Blakemore, 2012: 145] and other *Amynthas*/*Metaphire* spp. A large black leech (Hirudinea) was also present at the Hikone site (it was found in same vicinity as *D. hattamimizu*). [Note that *Eukerria saltensis* (Beddard, 1895) was located during this brief survey of an hour or so however casts looking similar to those it produces were seen around some fields]. All specimens in LBM. Later studies found yet more species, including a new Asian record for *Microdrilus dubius*, making the Satoyama habitat of Lake Biwa the most biodiverse in Japan, after the Tokyo megalopolis (see Blakemore, 2010, 2011, 2012).

Thus the biodiversity and distributions of the 28-30 species may act as indicators to monitor soil pollution/health. An interesting result of the Lake Biwa work was unexpected activity of both clitellate (breeding) adults and juveniles in an unseasonably warm winter, despite snow on the final day of survey in February, 2007.

Apparent high diversity reports are mainly due to eco-taxonomy that records smaller species and recognizes persistence of natives, combined with contributions from the pool of exotics originating from various temperate and tropical regions of the world.

A selection of earthworm abundance and diversity studies in Australia is presented in a table below (Table 1), this can be compared to results from other regions (Darwin, 1881; Lee, 1985; Edwards & Bohlen, 1996; etc.).

A summary of biodiversity of all non-native species in India, China, SEAsia/Australasia, Oceania and the Americas is in the Appendix attached (Table 8).

Coupland & McDonald (2008) report high populations of *P. litoralis* of 750-4,875 m^{-2} under wrack material on arid beaches in Western Australia and they calculated that earthworms could consume approximately 19- 31 kg m^{-2} yr^{-1} organic material there.

One of the highest enchytraeid mean abundance reports was of ca. 200,000 m^{-2} at Moor House (England) (as under-reported in Lavelle & Spain, 2002: 281).

Waters (1956) found high earthworm population in NZ, as reported in Lee (1959: 354): "A. caliginosa i*s the most common earthworm in New Zealand. It is found throughout the region, in the soils of pasture lands, cultivated lands, exotic forests and plantations, and occasionally under native vegetation. Very large populations, up to more than three million per acre (see Waters, 1956, p. 521), are encountered in the soils of high producing pastures.*"

This abundance equals 7.4 million worms per hectare, a high count but one exceeded in a single sample from Mokai near Taupo having double the equivalent population at 14.8 million although paddock average was ~7.2 million ha^{-2} (RJB "Breaking New Ground?" geothermal species survey, 2011).

More usually, populations of earthworms in rich organic soils range up to 1,000~2,000 m^{-2} (10-20 million per ha) with biomass as high as 5,000 kg ha^{-1} (5t ha^{-1}); and smaller worms and enchytreids may number up to 300,000 m^{-2} (e.g. Springet, 1967: fig. 24. pg. 78), nematodes number in the millions m^{-2}, oribatid mites up to 250,000 m^{-2}, and innumerable protozoans can equal or exceed the biomass of the earthworms. Naturally microbes are the most abundant and diverse in most habitats.

Total animal biomass of a typically fertile soil (excluding bacteria/archaea/fungi) is estimated at 2.5 t ha^{-1} (Ref) for which the earthworms make up the bulk of this as shown in the following table of soil fauna populations typical of temperate regions (after Gobat *et al.* 2004: 41-42, tab. 2.11; cf. Lee, 1985: tab. 7 and Table 3 following below).

Table 1. Averages of abundance and total animal biomass of a typically fertile soil

Group	**Individuals m^{-2}(approx.)**	**Biomass g m^{-2}**
Protozoa	10^{10}	6-30
Nematoda	10^{6}	1-30
Earthworms	50-2,000*	20-500*
Acari	10^{4}	0.2-4
Collembola	10^{4}	0.2-4
Insecta larvae	50-500	4.5
Myriapoda/Diplopoda	20-700	0.5-12.5
Myriapoda/Chilopoda	100-400	1-10
Isopoda	Up to 1,800	Up to 4

*Maxima from Gobat *et al*. 2004: 1,000 m^{-2} & 5,000 $kgha^{-1}$ (=500 gm^{-2} but possibly dry wt?); cf. Lee's (1985) maxima of about 2,000 m^{-2} & 300 gm^{-2}.

Table 2. Reports of Diversity and Abundance in Various Habitats of Australia after Blakemore (1994 PhD thesis) plus recent data with highest figures bolded.

State or Territory	Habitat	Taxa[A]	Total spp	No.s (m^{-2})	Biomass (g m^{-2})	Reference
SA	Wheat/fallow	exotics	3	20-450	2-74	Barley (1959a)
SA	Pasture	exotics	3	260-640	51-**152**	Barley (1959a)
NSW	Alpine forest	natives	10	7-135	1.2-81.8	Wood (1974)
Vict.	Woodland	natives?	N/A	25-195	N/A	Ashton, 1975
Vict.	Orchards	exot & nat	5?	0-**2,000**	N/A	Tisdall, 1978
Qld	Rainforest	natives?	N/A	140-150	N/A	Plowman, 1979
WA	Wheatbelt	exotics	4	N/A	N/A	Abbott & Parker, 1980

Vict.	Pasture	lumbricid	5	15-21	N/A	Tisdall, 1985
WA	Jarrrah forest	natives	7[B]	4-91	0.3-27.0	Abbott, 1985a; 1985b
WA	Pasture	exotics	5	19-157	8-61	Abbott, 1985a
WA	Pasture	Native	1	N/A	30-96	Abbott *et al.*, 1985
SA	Wheat	lumbricid	1	130-341	21-100	Rovira *et al.*, 1987
Vict/NSW	pasture/crops	exotics & natives	9	0-802	N/A	Mele, 1991
Qld	Barley	lumbricid	1	9-54	0.3-5.3	Thompson, 1992
WA	Pasture	exotics	2	58-170	20-90	McCredie *et al.*, 1992
Qld Narayan	Pasture	natives & exotics	6	0-1,020	0-31.1	Blakemore, 1994a
Qld Samford	Arable	exotics & natives	**24**	0-263.8	0-68.1	Blakemore, 1994a
Tas. Lake Pedder	sclerophyll wilderness	natives & exotics	**24**	NA	NA	Blakemore, 2000b
NSW	Pasture	exotics & natives	16	NA	NA	Blakemore, 2001c
WA	Under beach wrack	*P. litoralis*	1	750-**4,875**	NA	Coupland & McDonald, 2008

[A] exotic or introduced taxa are from various families; natives are mainly megascolecids, or in Queensland, Megascolecids + Acanthodrilids.
[B] maxima per site although 62 "*morpho-species*", representing an unknown number of native taxa, were identified from the region (Abbott, 1985b). N/A - data not available.
NOTE: Several mainly Southern Australian reports of low species diversity and mainly of exotics such as 'lumbricids' most often merely indicate poor sampling or poor taxonomy, or both. Proper eco-taxonomic re-survey should reveal their true status. For global figures in Lee (1985: tab. 7) I calculate overall means of **273 m^{-2} and 63 gm^{-2}.**

Global numbers, biomass and productivity approximations

Darwin's (1881: 158) calculated from Hensen (1877: 360) that there must exist 133,000 living worms in a hectare of land (ca. 13.3 m^{-2}) with 3 g per worm (Darwin mistakes this for 1 g) (= 0.04 kg m^{-2}), or 53,767 in an acre with this latter number of worms weighing 356 pounds per acre. Given figures in Table 2a below of global land areas, the likely fertile topsoil that supports earthworms is 5.4 + 4.1 or roughly 9.5 Gha. Thus total earthworms would be (133,000 x 9.5 Gha) = 1.3 x 10^{15} or 1.3 quadrillion, with (0.4 t ha^{-1} x 9.5 Gha) = 3.8 Gt biomass.

As a cross-check of accuracy, Dr Ken Lee (1985: tab. 7) has summary with average of 273 m^{-2} and 63 g/m^2 (= 0.63 t ha^{-1}) for a range of biome habitats (0.63 x 9.5 Gha fertile soils) = ~6.0 Gt total earthworm biomass. If global non-ice/sand topsoil land

were taken as 12.1 Gha (Ref), this gives (0.63 x 12.1 Gha) = 7.6 Gt or just about double the result from Darwin's figures.

From Lee's (1985: 33) reference text on Earthworm Ecology, their moisture content is 70%, thus 30% dry, so a total is of between 1.14 to 2.28 Gt dry biomass.

However these figures are low estimates because earthworms in fertile soils are more likely in the orders of 50-500 m^{-2} and 20-400 gm^{-2} (from Table 1 above). Thus the maximum numbers and biomass from maxima of 500 m^{-2} and 400 gm^{-2} would be (500 x 10,000 x 9.5 Gha) = 48 x 10^{15} and (4 t ha^{-1} x 9.5 Gha) = 38 Gt biomass globally.

Earth's human population is 7 billion and 0.35 Gt (mean ca. 50 kg each), thus totals give 7 million worms per person with 100 times biomass of all humanity!

Median values from above of 225 m^{-2} and 240 g m^{-2} total 21 x 10^{15} and 23 Gt; however, all values may be depleted as land suitable for earthworms erodes or they may be doubled to account for topography and micro-terrain (see Blakemore, 2016; 2018).

Table 2a. World area under agriculture and pasture recalculated from FAOSTAT, 2013, 2015; World Bank, 2015 and IAEES, 2015 (proportional figures in braces).

Category	World land area billion ha (Gha)	% land area (approx.)
Agriculture (total)	5.4 (i.e. managed lands)	36
as pasture/fodder crops	(3.6)	(24)
as arable (cultivated)	(1.6)	(11)
as permanent plantation	(0.2)	(1)
Forest and woodland area	4.1 (~60% virgin : 40% secondary)	28
Land not farmed	5.0 (e.g. desert, ice, mounts, grass)	33
Urban	0.4	3
Total land area	14.9 (minimum due to terrain!!)*	100

*Blakemore (2016, and in prep.) estimates terrain can double or quadruple total land area.

The UNEP Cambridge (2002: tab. 2.1) "World Atlas of Biodiversity" has total carbon content of Earth as 100,000,000 Gt, allocated as in the following table.

CARBON STORE		Gt	Gt
In sedimentary rock	organic	16,000,000	
	carbonate	65,000,000	
Active carbon near surface		40,000	
of which			
Dissolved inorganic carbon in sea			38,000
Organic carbon in soil			1,500
Atmospheric CO2 carbon			750
Biomass on land			**560**
Biomass in sea			**8**
TOTAL		81,040,000	

Note: Bacterial biomass is not included. Biomass on land is just the plants and not only underestimates underground stores but also ignores topography. Biomass in the sea is given as 5-10 Gt, here rounded up to 8 Gt which translates as just 1.4% of living biomass in the oceans and 98.6% on land. This is in contrast to Dr Sylvia Earle (2009) who claims that ocean is "*home for about 97% of life in the world, maybe in the universe*."

For microbial figures, an estimated is of 2.6 x 10^{29} prokaryotic cells alone, that harbour much of the earth's genetic diversity: One gramme of soil contains kilometres of fungal hyphae and a billion bacterial cells with tens of thousands of species (Ref, pg. 26).

A much-cited study (Whitman *et al*. 1998 Ref: tab. 5) of prokaryotes (bacteria + archaea) estimated total cellular Carbon biomass at 353-546 Pg (median = ~450 Gt now reduced to ~150 Gt!), that they claimed equalled the carbon storage in land plants (~560 Gt). Their allocation of prokaryotic cells (table 5) was approximately 367 x 10^{28} in oceans up to 276 x 10^{28} on land (with 305.2 Gt C in ocean and up to 241 Gt C on land). Their tab. 5 is newly recalculated here:

Number & biomass of prokaryotes in the world (after Whitman et al. 1998: tab. 5)

Environment	**No prokaryotic cells x 10^{28}**	**Pg (= Gt) C in prokaryotes**
Aquatic habitats	12 (in ocean, just 0.02 fresh)	0.6-2.2 (most in ocean)*
Oceanic subsurface	355 (now just 2.9)**	303 (now just 4.1)**
Soil	26 (terrain at least doubles it)	26 (possibly raised to ~200)
Terrestrial subsurface	25-250	22-215 (median 118)
Total (Whitman et al.)	**415-640**	**353-546**
*Totals recalculated	**66-291 (for lesser ocean)**	**54-247 (for lesser ocean)**

* In the text they give the rang in aquatic habitats, mainly ocean, as 0.6-2.2. Gt C.

** Global ocean sediment carbon was potentially reduced to 90 Gt for Archaea in a 2008 study (Ref), then Kallmeyer *et al*. (2012) reduced both this and the original 303 Gt C to just 4.1 Gt C. Carbon ratio from latter figure gives (2.2 + 4.1 =) 6.3 Gt ocean to 48-241 Gt land; thus the ocean contribution [6 in (48 + 6 = 54)] is at best 11% or, at worst, 6 in 247 = 2.4% and a reasonable median ratio for microbial life in sea to soil is just 6 : 144 or 4%. [Summary Ref].

But Whitman *et al*. (1998 Ref: tab. 2) have land estimates for flat-earth areas (total 12.3 Gha) multiplied by numbers of microbe cells sampled from each biome. It is likely that terrain will at least double the land count and thus the total biomass by at least one third. Furthermore, the recent ocean assessment (Kallmeyer *et al*. 2012) reduced microbial biomass on the seafloor to just 4.1 billion tonnes of C representing just 0.6%

of Earth's total living biomass. Thus land's allocation is yet again greatly increased proportional to that of the ocean.

From table (Ref) of bacterial cells with about 50% water and dry cells about 50% carbon, thus dry wt bacteria may total ca. 100-500 and wet biomass 200-1,000 Gt globally (median 600 Gt); allocation 144 x 4 = 576 land, 6.3 x 4 = 25 ocean.

Tables of biomass give new total 560 + 144 (median) = 704 Gt C for land and 8 + 6.3 = 14.3 Gt C for sea (or just 2% of 718.3 Gt total biotic carbon). Animals & fungi contribute too (see below), dry biomass data from Smil (2011) are:
Protists (single cell animals other than bacteria) – 10 Gt; Fungi – 5 Gt; Animals 2.5 Gt (but possibly add 1 Gt for earthworms that have gut full of soil, and assume he has included the 0.5 for global fish dry mass, = 3.5). Since carbon is about 50% of dry mass, then total other animals and fungi are 5 + 2.5 + 1.75) = 9.25. Thus estimate of all global living carbon is 718.3 + 9.25 = 728.5 Gt, or just a bit less than atmospheric carbon at about 750-800 Gt. This is newly calculated here (10th June, 2017).

For food production, FAO Statistical Yearbook (2013: 130) says: "*Of the approximately 2.3 billion tonnes of cereals currently produced, roughly 1 billion tonnes is destined for food use, 750 million tonnes is employed as animal feed, and the remaining 500 million tonnes is processed for industrial use, used as seed or wasted*."

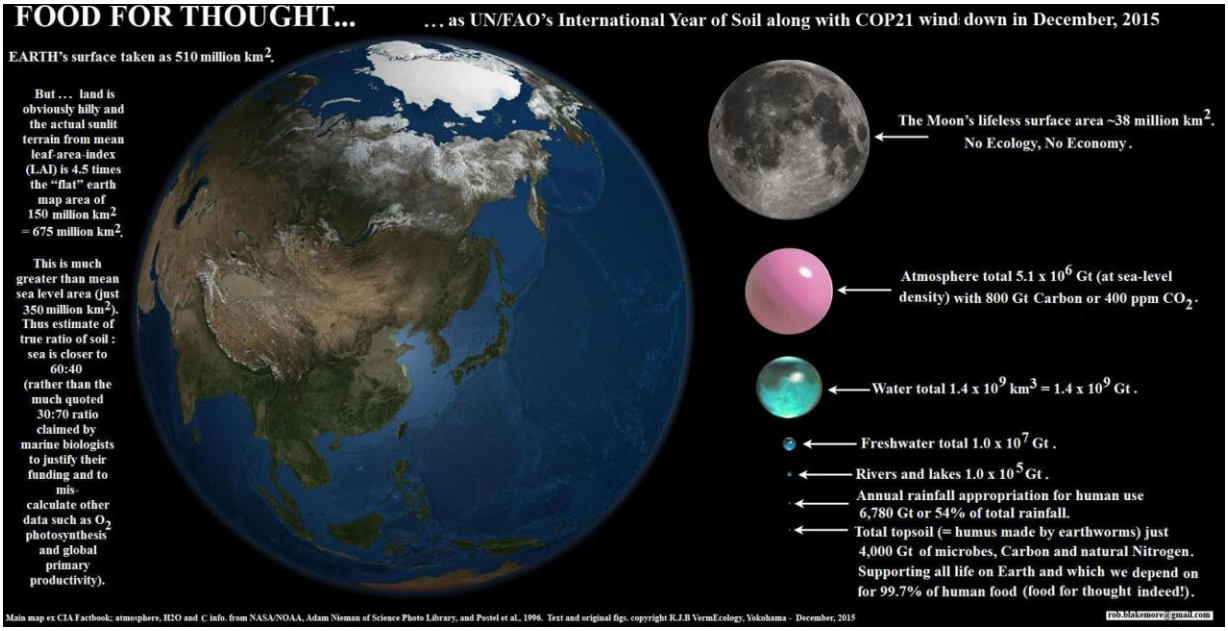
Surprisingly, since it is basic information about the planet's support system, accurate figures are not readily available for total (dry) humus in Earth's topsoil. Low estimates from Burningh (1984) and, partly, from Kovda (1974) of about 2,400 Gt comprising ca. 1,400 Gt of carbon that is about the same as 1,500 Gt C proffered by http://4p1000.org (from IPCC, 2012; cf. from NASA*, 2011 which has 2,300 Gt C). Whereas a highest estimate by Bohn (1976) is 3,000 ± 500 Gt of SOC (and since SOM = 1.72 x SOC this gives maximum of 6,020 Gt global humus). Thus a range estimate is 2,400-6,020 Gt, or median 4,210 Gt dry humus globally, or about equal to annual human water volume use (~4,000 km^3 yr^{-1} = 4,000 Gt yr^{-1} H_2O from FAO, 2014a). However, none of these calculations take into account the extra surface area of land when topography is taken into consideration (Blakemore, 2012; 2017). This may easily double land surface areas and, at increasingly higher scales of observation, increase it several fold [I estimate up to 4 times as for the global Leaf-Area-Index (LAI) that is 4.5 times footprint]. Nevertheless, it may reasonably be argued that topsoil is a more limited and therefore more valuable

global commodity than water because its replacement time is much longer: often quoted at a scale of decades or centuries rather than annually for rainwater.

Darwin (1881: 173) estimated 15 tons (actually his mean is 14.09 tons) of earthworm surface castings per acre on pasture/commons (= 33.6 t ha^{-1} yr^{-1} x 1.6 Gha arable land = 54 Gt yr^{-1} globally), this about equal to nett topsoil loss of 33 Gt yr^{-1} from FAO (2015)]. However, a huge discrepancy is that FAO (2015: 103) now estimate just 0.15 t ha^{-1} yr^{-1} topsoil formation; if on 9.5 Gha of non-ice/desert land = 1.4 Gt yr^{-1} globally. Possibly this is due to the demise of earthworms under agrichemical farming.

Nevertheless, the top 3 m of soil has >24 kg m^{-2} of Organic Carbon (= 2,300 Gt globally)* locked up in living soil organisms and the humic matter (plus glomalin) they consume and recycle (Ref., Ref.). Organic farming can substantially preserve high levels of earthworms, H_20 and Organic C with high yields, as demonstrated 35 yrs ago in studies at pioneering Haughley Experimental site (Blakemore, 1981, 1996, 2000).

The following figure graphically summarizes the data (from Blakemore, 2015).


FOOD FOR THOUGHT...
... as UN/FAO's International Year of Soil along with COP21 wind down in December, 2015
EARTH's surface taken as 510 million km².
But ... land is obviously hilly and the actual sunlit terrain from mean leaf-area-index (LAI) is 4.5 times the "flat" earth map area of 150 million km² = 675 million km².
This is much greater than mean sea level area (just 350 million km²). Thus estimate of true ratio of soil : sea is closer to 60:40 (rather than the much quoted 30:70 ratio claimed by marine biologists to justify their funding and to mis-calculate other data such as O2 photosynthesis and global primary productivity).
The Moon's lifeless surface area ~38 million km². No Ecology, No Economy.
Atmosphere total 5.1 x 10⁶ Gt (at sea-level density) with 800 Gt Carbon or 400 ppm CO2.
Water total 1.4 x 10⁹ km³ = 1.4 x 10⁹ Gt.
Freshwater total 1.0 x 10⁷ Gt.
Rivers and lakes 1.0 x 10⁵ Gt.
Annual rainfall appropriation for human use 6,780 Gt or 54% of total rainfall.
Total topsoil (= humus made by earthworms) just 4,000 Gt of microbes, Carbon and natural Nitrogen. Supporting all life on Earth and which we depend on for 99.7% of human food (food for thought indeed!).
Main map ex CIA Factbook; atmosphere, H2O and C info. from NASA/NOAA, Adam Nieman of Science Photo Library, and Postel et al., 1996. Text and original figs. copyright R.J.B VermEcology, Yokohama - December, 2015
rob.blakemore@gmail.com

Comparison of global surface area and relative volumes of air, water and humic topsoil, the latter apparently less than total rainfall appropriation (RJB, 2015).

Note that humus mean bulk density I newly calculate as 0.315 (n= 23) from Ref., thus the humus dot should be approximately same volume as a total rainfall volume.

*NASA has C in soil (>2,300 Gt at 0-3 m depth from the original sources I traced) equal to all plants (550, but mainly above ground?) + air (800) + oceans (1,000) combined!

Interestingly, the only summary comprehensive figures I can find for global biomass are from Bill Gates' website - www.gatesnotes.com/Books/Harvesting-The-Biosphere from Smil, V. (2011) Harvesting the Biosphere. MIT Press. This data now old.

In summary, total life on earth is 1,600 Gt (I think these are all dry weights from Smil's book; and I note that C is ca. 50% of dry mass and wet weights are about 50-70%), comprised:

Plants – 1,100 Gt [if wet weight may be 2,200?]
- Forests – 900 Gt
- Grasslands – 100 Gt
- Others – 100 Gt

Bacteria – 500 Gt [this is top range of my estimate above for dry wt = 1,000 Gt wet?]
- Subterranean – 200 Gt
- Subsea Sediments – 200 Gt [revision substantially reduced this figure to ~8 Gt]
- Soil Bacteria – 50 Gt
- Aquatic Bacteria – 5 Gt
- Others – 5 Gt
- TOTAL – 500 Gt [**but less the sub-sea over-estimation gives 308 Gt**].

Protists (single cell animals) – 10 Gt [maybe 20 Gt if wet]

Fungi – 5 Gt [maybe 10 Gt if wet].

Animals 2.5 Gt [maybe 5 Gt if wet].
- Land invertebrates – 1.5 Gt [earthworms are obviously under-represented as my figures show that they alone represent about 1.14-2.28 Gt dry mass].
- Marine Animals – 0.5 Gt [the latest figures for fish are 0.8-2 Gt "wet weight" but dry is about 0.16-0.4 Gt thus maybe correct; krill are 0.379 Gt wet, maybe 0.07 Gt dry].
- Domestic Animals – 0.3 Gt
- Humans – 0.125 Gt
- Wild vertebrates – 0.01 Gt
- TOTAL = 2.525 Gt [updating earthworms 2.525 + 1-2 dry = ~4.0 Gt = 8 Gt wet].

Total life may be (791 Gt C x 2) = 1,582 Gt on land + (14.2 Gt C x 2) = 28.4 in sea to give (1,582 + 28.4) = 1,610.4 Gt dry (Ref). Sub-surface biomass (fungi & roots) may double land proportion (1,582 x 2) = 3,164 and terrain may double it again (3,164 x 2) = to 6,328 Gt on land plus 28.4 in sea to total 6,356.4 Gt dry biomass. If water content is taken as 50% [about 30% in wood (Ref) and 50-70% in bacteria (Ref1, Ref2) gives median ~50%] then this value is doubled again to about 12,712.8 Gt plus 16 Gt worms, 2 Gt fish (Ref1, Ref2) and 25 Gt other animals gives a substantial new total for Earth's living, respiring biomass of ~12,755.4 Gt (cf. Ref).

Biodiversity resources and regional distributions

Since Michaelsen's (1900) *Das Tierreich: Vermes* reviewed all 1,200 species of oligochaetes then known, taxonomic efforts have overwhelmed and polarized researchers either to the aquatic microdriles, or to the terrestrial megadriles (i.e., the 'true' earthworms) [see Benham (1890); Michaelsen (1903: fig1 of bio-regions fig2 of northern glaciation limits). Updated indices of most names are provided in a *Nomenclatura Oligochatologica* series by Reynolds & Cook (1976; 1981; 1989, 1993; and, since 2000, in prep.) that list all names regardless of synonymies. As at December, 2005 these nominal taxa approximated as: 38 Families; 804 Genera; 61 Sub-genera, and ~ 8,500 Species divided roughly 50 : 50 into aquatic microdriles plus enchytraeids : terrestrial megadriles (extrapolated from Wetzel, 2006). The ratio of species to genera to families is about 225:21:1 (with almost half the relative number of families as the Polychaeta have at 100:12:1 for their valid species - see below).

Oft quoted but unverified, earlier calculation by Reynolds (1994: 15) were of nearly 8,000 described Oligochaeta, with just 3,600 terrestrial megadriles [presumably ~4,400 microdriles??], and, from previous trends, an estimate of ~50 years to double the number of described species to 7,200 spp – these figures quoted by Fragoso *et al.* (2003: 400-404) and see their Ref, (May, 2005) that states:

"*The annelids were among the first animals to evolve on the face of the earth, probably appearing in the Edicarian Period (Paleozoic Era), >600 million years ago. It is estimated that there are today over 7000 species of terrestrial oligochaetes, of which we know only about 3600*". [**This number is mistaken as now over 7,000 known species and several thousand more unknown**].

A Zoobank (Dec. '08) total for Oligochaeta (microdriles + megadriles with multiple entries for some species) was **12,212** species, genera and family names while an online catalogue (see http://earthworms.elte.hu/) by Dr Csaba Csuzdi (2012 Ref.) currently (June, 2013) lists ca. 7,000 megadrile spp (but about 200 names are more properly for microdriles) so that a total is >**6,800 megadriles names**. And, if we add the 3,600-4,400 or so microdrile names determined from Reynolds (1994) and Wetzel (2006, website) (with just ca. 1,700 valid spp according to Martin *et al.*, 2007), this would give a **Total Oligochaeta of ~10,400-11,200 taxa** with an unknown number of synonyms, subspecies or cryptics, these arranged in ca. 804 Genera (+ 61 mostly unnecessary Sub-genera) and 38 Families. The author (RJB) has compiled several checklists: e.g. for Holarctic Lumbricidae (ca. 670 valid spp from a total of around

1,150 names), and Oriental pheretimoids (~940 valid spp from ca. 1,400 nominal taxa). These most current datasets still have many *species incertae sedis* or *species inquirendae* that require resolution from inspection of types. Yet probably much less than a quarter of earthworms from around the world are known. For example, Tasmanian studies by the present author increased species total of this island, that was claimed to be relatively well-studied, four-fold: from 55 to 230 taxa (Blakemore, 2000), and recently added names have nearly doubled the faunas of Japan, Taiwan and other Asian countries (see Blakemore, 2002, 2003, 2005, 2006, 2007, 2008, 2010).

For earthworms as a whole, a conservative estimate was made for the description of a further 3,000 taxa in the next 10 year with 46 full-time taxonomists, or 46 years with 10 taxonomists (Fragoso, *et al.*, 2003: 404). Such an effort – and now at the close of 2012 this seems increasingly unrealistic – would have raised the numbers of megadriles (including Moniligastridae) from the current total (as estimated above at ca. 7,000) to ca. 10,000 spp. and thus total Oligochaeta (microdriles + megadriles) to >14,000 taxa thus exceeding the nominal Polychaeta (ca. 13,000 spp) as noted next.

In comparison, this total matches the current marine polychaete fauna. In Australia some 67 families, 420 genera and ca. 1,140 species are known and a comparable extimate of **Total Polychaeta** is of about 13,000 names (cf. Dec. '08 Zoobank lists **21260** names), although only 8,000 of these were considered reasonable species and these are in 1,000 genera and 82 families - this data from Dr Chris Glasby: http://www.ea.gov.au/biodiversity/abrs/online-resources/polikey/index.html#history (Dec. 2006). Their ratio spp.:genera:families = 160:12:1 or perhaps 100:12:1 for valid species. But this is biodivdersity is mostly a product of the much greater number of full-time taxonomists working on this group [about 300 workers are listed on the Polychaete Researchers Online (PRO) website - about 30 times greater than the number of Oligochaeta taxonomists worldwide]. Moreover, whereas there are many countries with many Marine Research Centres (e.g. AIMS), there is not one dedicated "Soil Ecology Institute", a notable exception is the Czech Institute of Soil Biology (http://www.upb.cas.cz/?jazyk=en&co=basic) that is a modest venture. With the similar resources and funding to the marine sciences, many more earthworm species could be unearthed and ther ecologies studied, however numerable synonymies exist for those already named reducing the number of taxa whilst others are claimed as cryptic species complexes increasing their numbers, so the true absolute total figures remain uncertain.

Justification for study of Polychaeta, from a quote from POLIKEY website:

[http://www.deh.gov.au/biodiversity/abrs/online-resources/polikey/#polychaetes]

"*Polychaetes are an important group both ecologically and economically. Ecologically, they are at (or near) the base of many food chains involving commercially important fish and shellfish species, they are common commensal organisms, they play a major role in nutrient recycling, some tubiculous species are reef builders, boring species are reef destroyers, and some species are bioindicators of the health of marine ecosystems. Polychaetes are also an important economically in both positive and negative ways. Species of Nereididae, Glyceridae, Onuphidae and Eunicidae are cultured or wild-harvested for bait or for use as feed in fish and shellfish mariculture. Parasitic species may have a negative effect on the shellfish (e.g. oysters) and others have a negative effect on shipping (hull fouling) and power stations (fouling water intake pipes). from a scientific point of view, polychaetes are a key group in phylogenetic studies of the evolution of complex invertebrates and a model group in studies of invertebrate reproduction and development. Polychaetes are an ancient group dating back to the Middle Cambrian (540 million years ago), and possibly earlier.*"

If this is true for Polychaetes, then the ecological and economic importance of Oligochaetes must be 1000's times this considering that >99% of the world's food (and fibre) supply is produced on land, whereas only 0.6% comes from oceans and other aquatic ecosystems (FAO 1991); and other scientific merits are equable. Despite this, the Oligochaeta with ca. 10,000 spp has less than 10 workers, while Polychaeta with 13,000 known taxa (ca. 8,000 valid spp) has 300 workers. Thus, under-funding of soil eco-taxonomic research on terrestrial Oligochaetes in favor of marine taxonomic ventures is arguably an unbalanced economic and ecological decision.

"Annelid Resources" is an ANNELIDA Worm Biodiversity site, mainly for Polychaetes, linked to a website maintained by Dr Geoffrey Read at NIWA, New Zealand, see http://biocollections.org/pub/worms/res-res.html#POLY [Jan, 2006]. This site hosts info on the International Polychaetology Association (IPO Jan. 2006).

Even the lesser microdriles are well studied, e.g. an AQUATIC OLIGOCHAETOLOGISTS website [www.inhs.uiuc.edu/~mjwetzel/ISAOBdir.html July, 2006] includes over 340 scientists from 54 countries.

Other examples of successful working groups, that may be emulated by Oligochaetologists if there is enough motivation to co-operate, is the "Checklist of the Collembola" website that claims ca. 7,500 described species in about 33 families worldwide (about the same numbers as for Oligochaeta!) but which lists 178 researchers; see: www.geocities.com/CapeCanaveral/Lab/1300/doc/experts.htm [Jan. 2006] and www.collembola.org/; and the "Plant-Bug Systematic Catalogue" database that obtained publishers' permission to reproduce and redistribute publications on their taxa (see http://research.amnh.org/pbi/catalog/index.php).

At an IOTM Switzerland in 2011, as published in Blakemore (2012, 2017), I advocated a program to commission a "**Census of Soil Invertebrates**" (CoSI) to improve and offer more beneficial outcomes than the Marine Census (CoML $1billion, 10 yrs, only 250,000 spp total in oceans) despite 99.4% of human food and all our fibres and building materials coming from soil plus all terrestrial primary production and, due to erosion, also the nutrients and pollutants in the waterways and oceans too. The table below is adapted from my CoSI proposal (just inverts, not plants, etc.):

Table 3. Abundance & biodiversity estimates for common soil Invertebrates [from Brusaard *et al*. 1997; Wall & Moore 1999, Chapman 2009; Turbe *et al*. 2010: Tab. 1.; Fierer *et al*. 2007; Blakemore, 2012; Wiki (Ref) and pers. obs.]. Note: higher species have many unique symbionts/parasites too.

Soil Invertebrate Group	**Individuals m^{-2} (approx.)**	**Biomass g m^{-2}**	**Known species**	**% known**
Viruses (Fierer *et al*., 2007)			≈2,000-4,577	<0.5%?
Bacteria and Archaea	10^{12}	20-500*	≈7,500	<<1%?
Fungi	(500+ km)	20-500*	≈80,000	0.5%
Protozoa	10^{10}	6-30	1,500	8%
Rotifera (Bdelloid soil rotifers)	10^{5}	?	300	?
Nematoda	10^{6}	1-30	25,000	"1.3%"
Lobopodia (Onychophora, Tardigrada)			**~1,200**	**<<50%**
Lobopodia (Onychophora,)	*?*	*?*	*<200*	*50%*
Lobopodia (Tardigrada)			*~1,045*	*?*
Arachnida, Opiliones			6,300	?
Arachnida, Pseudoscorpionida			3,300	?
Acari (mites)	10^{4}	0.2-4	45,200	4%
Hexapoda (totals)	**10^{4}**	**0.2-4**	**~9,000**	**17%**
Hexapoda (Collembola)	*Up to 100,000*		*6,500*	
Hexapoda (Diplura)			*800*	
Hexapoda (Protrura coneheads)			*731*	
Soil Insecta and their larvae	50-500	4.5	55,000+?	20%?
Myriapoda (centi-, millipedes)	**100-1,100**	**1.5-22.5**	**18,000**	**20%**
Myriapoda (Symphyla)			*200*	
Pauropoda (Myriapoda relative)			*700*	
Isopoda (slaters, woodlice, etc.)	Up to 1,800	<4	5,000	?
Isoptera (Termites)	Colonies	?	2,600	60%?
Blattodea (Cockroaches)	?	?	4,500	?
Ants (Hymenoptera : Formicidae)	Colonies	?	13,000	50%
Molluscs (Soil Gastropods)	?	?	24,000	40%?
Terrestrial Turbellaria (Planarians)	?	?	830+	?
Terrestrial Polychaeta	?	?	?	?
Oligochaeta (Mega-, Microdriles)	**50-5,000**	**20-500**	**10,000**	**20%?**
Microdriles (Enchytraeidae)	*1,000-300,000*	*1-53*	*~700*	*?*
Microdriles (excluding enchytraeid)	*?*	*?*	*1-2,300??*	*?*
Megadriles (true earthworms)	*50-4,875**	*20-305**	*7,000*	*<20%?*
Total species (approx.)			**315,500**	**?**

* Sub-surface biomass (even excluding plant roots & tubers) exceeds that above-ground. Lee (1985: tab. 7) has highest earthworms in NZ pastures (2,020 m^{-2}, 305 gm^{-2} from McColl & Lautour, 1978). Coupland & McDonald (2008) report *P. litoralis* at 750-4,875 m^{-2}. Enchyraeid maxima are from Springett (1967: fig. 24) / Gragg (1963: tab. 2) at Moor House, (mis)quoted by Spain & Lavelle (2001).

Brockie & Moeed (1982 https://www.jstor.org/stable/4218006?seq=1#fndtn-page_scan_tab_contents) claim NZ forest earthworms (just 333 kg/ha = 33.3 gm^{-2}) have most animal biomass; cf. insects 145, mammals (exotics) 25, and birds 0.6 kg/ha.

Some data for microbes in the table above are extracted from the EU Union Soil Resource http://eusoils.jrc.ec.europa.eu/library/Themes/Biodiversity/Index.html which also provides the following information:-

"*Soil biodiversity carries a range of values that depend on the perspective from which they are being considered. These include:*

- ***Functional value**, relating to the natural services that the soil biota provides, the associated preservation of ecosystem structure and integrity, and ultimately the functioning of the planetary system via connections with the atmosphere and hydrosphere.*
- ***Utilitarian** ("direct use") value, which covers the commercial and subsistence benefits of soil organisms to humankind.*
- ***Intrinsic** ("non-use") value, which comprises social, aesthetic, cultural and ethical benefits*
- ***Bequest** ("serependic") value, relating to future but as yet unknown value of biodiversity to future planetary function or generations of humankind.*

The ecological value of soil biodiversity is increasingly appreciated as we understand more about its origins and consequences. The monetary value of ecosystem goods and services provided by soils and their associated terrestrial systems, an entirely human construct which assists putting their significance into an economic context, was estimated in 1997 to be thirteen trillion US dollars ($13,000,000,000,000). The soil biota underwrites much of this value."

They also state (http://ec.europa.eu/environment/soil/biodiversity.htm):

"*To date* (Sept. 2012)*, no legislation or regulation exists that is specifically targeted at soil biodiversity, whether at international, EU, national or regional level. This reflects the lack of awareness for soil biodiversity and its value, as well as the complexity of the subject. The management of soil communities could form the basis for the conservation of many endangered plants and animals, as soil biota steer plant diversity and many of the regulating ecosystem services. This aspect could be taken into account or highlighted in future biodiversity policies and initiatives.*"

Finally, their 2012 SOILSERVICE Summary (Ref.) advocates just what I have for the last 30 years: i.e., ORGANIC FARMING in order to reduce artificial fertilizers/pesticides (and now GMOs!) pollution, thus restoring soil C and reviving diminishing soil biodiversity whilst also sustainable healthy food/soil/energy security.

That soil and soil biodiversity is so neglected and overlooked is of major concern. The Millennium Ecosystem Assessment (MEA 2005) ignored soil as a key habitat, and its successor, the UN's 2015 "***Sustainable Development Goals***" (Ref. - http://www.globalgoals.org/) does too. Of the 17 goals, the nearest is #15 for "Life on Land" (https://sustainabledevelopment.un.org/sdg15 as opposed to #14 for "Life below water" – there is never "**Life below soil**"!!) but this too has been kidnapped by the ocean/water, microbe and forest interest gangs; as for biodiversity the only examples given are of coastal corals and aquatic amphibians! Soil is only mentioned once!! Search of their Sustainable Development Knowledge Platform (Aug. 2017 - https://sustainabledevelopment.un.org/index.php?page=view&type=255&nr=2527&menu=35) is telling. Here are some reference search result hits:

"earthworm" – 5 (even though earthworms make the soil)

"soil" – 755 (even though we depend on soil for >99% of food and biodiversity)

"fish" – 1,262 (even thought these provide <1% of human food)

"forest" – 1,392 (about twice the soil result)

"ocean" – 1,651 (about twice the forest or soil results)

"water" – 3,407 (about twice the ocean result and five times soil result)

The dilemma is summarized in a quote from Koch *et al*. (2016: 3-4): "*Discussions around biodiversity loss seldom refer to soil even though soil contains the most diverse and complex ecosystems on the planet. Soils contain over 98 per cent of the genetic diversity in terrestrial ecosystems (Fierer et al., 2007)* however soil biodiversity is not addressed in the Global Biodiversity Outlook (GBO-3) from the UN Convention on Biological Diversity (Secretariat of the CBD, 2010), and is not referred to in the popular International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2012).*

Recent attempts to develop a global framework for assessing planetary resources also fail to recognize the vital role of soil in the biosphere. The Stockholm Resilience Centre led an effort to define the key planetary boundaries that face anthropogenic pressure (Rockstrom et al., 2009). This important work is influential in current reviews of sustainable development, but does not address soil as a critical contributor to buffering the thresholds of those boundaries."

*NOTE: Fierer, N., Breitbart, M., Nulton, J., Salamon, P., Lozupone, C., Jones, R., et al. (2007) Metagenomic and Small-subunit rRNA Analyses Reveal the Genetic Diversity of Bacteria, Archaea, Fungi, and Viruses in Soil Applied and Environmental Microbiology , 73, pp. 7059 – 7066. http://aem.asm.org/content/73/21/7059.full Makes no mention of such a figure as 98% SOIL BIODIVERSITY, this is just the genetic difference cutoff!!

Of particular concern/deepest frustration to me is that the only advocates for soil are themselves guilty of ignoring earthworms. For example, Koch *et al*. (2016) make no mention of "earthworm" in their summary, but neither does McBrateny *et al*. 2017) in Field *et al*. 2017), except for once, in a fully edited GLOBAL SOIL SECURITY.

Chorology [Chorology (from Greek *khoros* - place) can mean the study of the causal relations between geographical phenomena, such as climate or altitude, occurring within a particular region, and also the study of the spatial distribution of organisms].

"*Soils – The Final Frontier*"

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Meaningful biodiversity comparison requires representative estimation from reliable survey (e.g. considering numbers and size of samples, depth, various habitats, and seasonal differences) and correct identification of community components (specific and ecological categorization). See "Collection" under later ECO-TAXONOMY section. Difficulties include the amount of work required for adequate sampling and hand sorting of soils, and the lack of complete and consistent species guides. I have seen soil survey results that used entirely inadequate 5 cm core samples and then have claimed that "*earthworm populations are negligible*". I have also seen reports from a rather 'half-Baked' "*National Survey of the Earthworm Fauna of Urban and Agricultural Soils in Australia*" that only used superficial samples eagerly collected by school children and, for identification, an inappropriate British field guide (Sims & Gerard, 1985) and which failed to attempt any dissection to confirm species identities thus producing, unsurprisingly, a highly dubious and unprofessional result of just 27 species from the whole of Australia (and many of these were probable misidentification unconfirmable due to lack of vouchers) – again, as in case 4 below:

Contingency table of sampling reliability

Case	Ecological sampling	Taxonomic treatment	Results
1	+	+	Representative data
2	+	-	Under/over-estimate
3	-	+	Under/over-estimate
4	-	-	Unrepresentative data

+, Good; -, Poor

A day's field sampling may easily result in at least a fortnight's laboratory/library work for proper identification, which is why museum shelves around the world are stacked with specimens vainly waiting identification and verification by specialists.

At the same time, a species is more than just a sample specimen in a jar. Taxonomic description should include as much ecological and behavioural information as possible, such as the species association, details of habitat, parasites,

predators, prey and so forth. Ideally the collector in the field will be the identifier too.

'**Eco-taxonomy**' or Ecological-taxonomy, as envisaged here implies combination of proficient ecological survey with competent taxonomic identification; including details of the species' associations, its behaviour, life-cycle, and its external and internal habitat to represent the species in its complexity and its entirety and the environment in its biodiversity and its community.

Expeditious publication of results is also required to provide answers.

Earthworm taxonomic surveys for various countries and regions have been produced sporadically, the most thorough often in the form of Monographs (e.g. Michaelsen, 1900; 1903). Some regional examples follow.

For the Australasian/Oriental region some pertinent references are: checklists for the whole of Australia, i.e., the mainland plus Tasmania, by Blakemore (1999; 2000; 2005; 2006/2007) of ca. 715 species in total with ca. 650 natives (including 202 natives from the small island state of Tasmanian) and approximately 67-69 exotics currently known, (ca. 9% of total species). If we add the dozen or so neo-endemics plus the two or three translocated natives in Tasmania, the total is raised to about 80 Australian non-endemics ca. 11% of the total) and, of these about 35% Lumbricidae (ca. 3% of total).

Further, it is estimated (e.g. by Blakemore, 2000) that the Australian total will be three or four times this number, especially since huge areas such as the Northern Territory have yet to be systematically surveyed: e.g. current records from NT are of just 20 species - about the same number as may be found on a single farm in the south.

Lee (1959a, 1959) published the epitome of eco-taxonomy for the earthworms of New Zealand (192 species + key), recently updated by Blakemore in Lee *et al.*, (2000) and Blakemore (2004h; 2005, 2006/7, 2010) to 212 spp (25 exotics). See also Massey University NZ Oligochaete website with good photographs of some worms [http://soilbugs.massey.ac.nz/oligochaeta.php].

Papuosia (PNG + W. Papua) has 115 species (19 exotic) – Blakemore (2006/7).

In Asia: Stephenson (1923), Julka (1988, and in press), and Julka & Paliwal, (2005) document Oligochaeta of India and adjacent countries (except Myanmar) of ca. 418 megadriles, with a current total of 505 species provided by Blakemore (2006/7) [see also www.zsienvis.in/Biodiversity/Fauna/17.%20Aannelida.doc]. Begum & Ishmail (2003) list and figure some Chennai species. Gates (1958) reviewed lumbricids exotic to the Orient; Gates (1972) listed 174 Myanmar taxa; Easton (1981)

and Blakemore (2003, 2005) described earthworms of Japan (ca. 82 valid species) including Ryukyus with ca. 27 species (17 exotic). Shih *et al*. (1999), Tsai *et al*. (2000), and Blakemore (2005; 2006/7) summarize species known from Asia: Taiwan 80 species (33 exotic) [about 30 other new pheretimoid species are in press – see recent review in booklet form by Chang *et al.* (2009): "*The earthworm fauna of Taiwan*" that is quite useful]. Mainland China had 105 species (23 exotic) but a current tally is >240 (Blakemore, 2006/7) – this includes Hainan that has 32 species (8 exotic) but currently excludes Taiwan (Ref.) [cf. Huang *et al.* (2006) for China including Taiwan]. Korea now has 96 species (ca. 23 exotic) – Blakemore (2005, 2006, 2008). Thai & Samphon (1991) had 68 spp from Laos, and Thai & Do (1989) had just 8 from the Cambodian plains, and Thai (2000) had 195 species from Vietnam (165 pheretimoids). All these Asian regional reviews have been revised and updated taxonomically and geographically by Blakemore (2005; 2006/7; and in press).

Mongolia is newly found to have four species (Blakemore, 2013).

An annotated checklist of Malaysian species, exhaustively compiled by Blakemore (2006), appears to have been copied to entirely comprise the Malaysian Encylcopedia-of-Life (MyEOL) website – without proper acknowledgement citation.

Guides for the whole of Africa do not exist. Michaelsen (1891) described all 73 then known species; Michaelsen (1910), (1903), (1913a) and (1913b) further treated the earthworms of tropical Congo, Nigeria and sub-tropical south Africa, Natal and Zululand, etc.; and Pickford (1937) produced a monograph of Acanthodriline earthworms of South Africa; a summary of introduced earthworms were by Ljungström (1972) and Sims (1978). In South Africa, Plisko (pers. com.) has endemic earthworms represented by almost 300 species belonging to the families Acanthodrilidae and Microchaetidae, some obviously undescribed as a website quotes Dr Danuta Plisko's list of 102 Acanthodrilidae and another 103 Microchaetidae from South Africa, all stated to be endemic: www.earthwatch.org/expeditions/hamer/hamer_04.pdf [see also Plisko (2006)]. East and West African worms were variously described by Michaelsen in several paper and also, for example, by Omodeo (1958) , Sims (1967, 1978, 1985), Martha Weis Clausen (2004); Sao Tomé species are reviewed by Csuzdi (2005), and later papers by Csuzdi & Zicsi (Refs.) also treat various African species groups.

Canary Island (Canaries) taxa are online here: (Talavera, 2006; 2007a; 2007b).

Blakemore (2005; 2006/7) summarized and tabulated faunal records for whole of the Pacific/Oceania and for sub-Antarctic island taxa in the Southern Ocean based on works by Lee (1968; 1981), Gates (1969) and Easton (1984) and various other sources.

Gates (1969) refered to The Juan Fernandez Islands: a SE Pacific archipelago off Chile comprising Robinson Crusoe Isl. formerly known as Más a Tierra (Closer to Land), Santa Clara and Alejandro Selkirk Isl. formerly as Más Afuera which is the largest island.

European earthworm faunas are relatively well reported [an EU *Fauna Europaea* (www.faunaeur.org/full_results.php?id=11870 Jan, 2007) lists 472 (sub)species for Suborder Lumbricina, but several taxa are obviously American; and EUNIS database has 505 megadriles with 463 Lumbricidae that includes many synonyms, see eunis.eea.europa.eu/species-taxonomy.jsp?idTaxonomy=616 Jan., 2007].

For the British Isles (UK and Ireland) Blakemore (2005; 2006/7) lists ca. 69 species, all thought to be introductions (Sims & Gerard, 1985; 1999: 23); *Polypheretima taprobanae* was thought a new record but was actually already known from Kew (*vide intra*) and *Pithemera bicincta* is from recent literature (Ref.), plus *Alma millsoni* (Beddard, 1891) from Kew Gardens that was overlooked by Beddard (1906), Sims & Gerard (1985, 1999) and others until now, plus *Kenleenus armadas* Blakemore, 2012 from an Urban farm in County Dublin and a farm in County Loath, (Keith & Schmidt, 2012 and http://www.ucd.ie/earth/people/academic/olafschmidt/publications/); E. Rota (pers. comm.) has recently reported *Eukerria saltensis* from the Thames near Kew Gardens plus the restored *Lumbricus herculeus* was also reported, but is unconfirmed, from Kew by Beddard (1906, along with approx. 38 other species from the Gardens, 21 first reported there). Blakemore's (2013) restoration of *Amynthas diffringens* brings the current total to ca. 76 species from the British Isles & Ireland.

These species were listed by Beddard as originating from samples sent to Kew Gardens from around the world (Ref.) - *Quarterly J. Microscop. Sci.* 32: 235-278, etc.:

Helodrilus lagosensis Beddard, 1891 from Lagos, Nigeria.

Hyperiodrilus africanus Beddard, 1891 from Lagos, Nigeria.

Ocnerodrilus eiseni Beddard, 1891 from Guyana.

Perichaeta specimens mixed with *M. mauritiana* from Mauritius.

Perichaeta barbadensis Beddard, 1892 = *Amynthas morrisi* from Barbados.

Perichaeta dyeri Beddard, 1892 = *Amynthas rodericensis* (Grube, 1879).

Perichaeta hesperidum Beddard, 1892 = *Metaphire californica* (Kinberg, 1866).

Perichaeta mauritiana Beddard, 1892 from Mauritius.

Perichaeta morrisi Beddard, 1892 = *Amynthas morrisi* from Penang, Malaysia.
Perichaeta sinensis Beddard, 1892 = *Amynthas rodericensis* (Grube, 1879) from China.
Perichaeta sumatrana Horst, 1883 = *Metaphire schmardae* from Barbados/HK.
***Perichaeta taprobanae* Beddard, 1892 = *Polypheretima taprobanae* from Sri Lanka.**
Perichaeta sp live specimens from Kew Gardens, imported from Singapore.
Gordiodrilus ditheca Beddard, 1892 from Lagos, Nigeria. 1 specimen.
Gordiodrilus dominicensis Beddard, 1892 from Dominica.
Gordiodrilus elegans Beddard, 1892 from Lagos, Nigeria.
Gordiodrilus robustus Beddard, 1892 = *Dorgiodrilus robustus* from Lagos, Nigeria.
Gordiodrilus tenuis Beddard, 1892 from "Assaba, west coast of Africa".
Trichochaeta hesperidum Beddard, 1893 = *Hesperoscolex hesperidum* from Jamaica.
Benhamia crassa Beddard, 1893 = *Dichogaster crassa* from Lagos, Nigeria.
Eudriloides durbanensis Beddard, 1893 from Durban, Natal.
Ilyogenia africana Beddard, 1893, ditto.
Microdrilus saliens Beddard, 1893 = *Dichogaster saliens* from Java and Penang.
Moniligaster bahamensis Beddard, 1893 from Bahamas.
Trichochaeta barbadensis Beddard, 1893 = *Hesperoscolex barbadensis* from Barbados.
Iridodrilus roseus Beddard, 1897 = *Hyperiodrilus roseus* from West Africa.
Amyntas alexandri Beddard, 1900 = *Amynthas alexandri* from Calcutta.
Typhoeus incommodus Beddard, 1901 = *Eutyphoeus incommodus*, ditto.
Typhoeus masoni Bourne, 1889 = *Eutyphoeus masoni* from Dehru Dun, India.
Typhoeus nicholsoni Beddard, 1901 = *Eutyphoeus nicholsoni* from Calcutta, India.

For France Bouché (1972) reported ca. 180 taxa (not all valid species names) and these were commented on and added to by Zicsi & Csuzdi (1999) and Qiu & Bouché (1998) to give totals of about 300 names (not all valid – see link). Austria has ca. 60 lumbricids (48 and 60 listed by Zicsi, 1965: 263; 1994 plus *Lumbricus friendi*, *O. complanatus*, and *Criodrilus lacuum*). Edwards & Lofty (1977) gave these examples of European records: (ex-)Czechoslovakia - 37 species (17 peregrine); Switzerland - 38 species (18 peregrine); Italy 57 - species (17 peregrine) [this total most recently updated as 86 megadriles from a total Oligochaeta of 304 species – ref.]; Germany - 24 species [19 peregrine, compare to 39 German lumbricidae listed online here (with many synonyms and other mistakes included) from Graff (1983) and Buch (1986) and Scwarz (1995)]. Bulgarian fauna is described by Zicsi & Csuzdi (1986) (54 spp); and Hungarian

fauna is described by Csuzdi & Zicsi (2003). The Balkan State of Serbia has 71 species and 8 subspecies, belonging to 18 lumbricid genera, with 45 (57%) identified as exotics (ref), some Serbian spp also mentioned here by authors who seem ignorant of the changes by Blakemore (2004, 2005, etc.). Montenegro has ~45 spp (Stojanovic & Karaman, 2003).

The Czech Republic species are listed here, and Pizl (1994; 2002) describes earthworms from the Czech Republic which also has a faunal website (http://www.biolib.cz/en/taxon/id20098) that appears copied from http://www.faunaitalia.it/checklist/invertebrates/families/Lumbricidae.html but it is not clear if all species occur there. Bulgarian worms were described by Cernosvitov (1937). Slovak species catalogued by Zajonc (1981) and some Romanian lumbricids are here.

In Poland, Plisko (1965; 1973) surveyed the Polish lumbricids (ca. 32 spp.). Michaelsen (1901) and Perel (1979: 263; 1997; updated by Blakemore, 2005; 2007) describes those from the former USSR, including Siberian species: (totals 113 species: 107 Lumbricidae and 6 species from 5 other families and ca. 50% of these endemic). Slovenian and Balkan species are described by Mrsic (1985; 1991). Macedonia has ~29 species (Ref. Jan., 2006).

Faunas of Greece, Portugal, Spain and Turkey (76 species) are found in Zicsi & Michalis (1981), Omodeo & Rota (1989), Trigo *et al.* (1990), Csuzdi *et al.* (2006; 2007), Mısırlıoğlu, Pavlíček & Csuzdi (2008).

A total Scandinavian earthworm fauna of 41 species in 4 families are recorded by Blakemore (2006/7). Previous regional reports tended to list only about 20 taxa in Lumbricidae only. Those from Norway were described by Stöp-Bowitz (1969) especially his Table IV "*Species of Lumbricidae found in Scandinavia and adjacent territories and in North America*" (p.260). Finland earthworm were catalogued by Karppinen & Nurminen (1964), and Terhivuo (1988; 1989). Swedish worms were described by Julin (1949); Sweden also has a SWORM project database of some 20 earthworm species [or http://www2.nrm.se/ev/dok/oligochl.html.en Jan. 2007]. Danish taxa (fifteen Lumbricidae species in 8 genera) are described by Clausen (1987; 1993) and about 20 Lumbricidae plus a note about Megascolediae and Eudrilidae in hot-houses are listed on Lars Skipper's website [http://hjem.get2net.dk/lars_skipper/regnorme3.htm that is supported with details from Skov-og Naturstyrelsen database on introduced taxa www.skovognatur.dk/natur/invasive_arter/images/introarter.xls Jan., 2007]. A few other

North Eastern Atlantic Taxa (NEAT) are listed in Hansson (1998) [http://www.tmbl.gu.se/libdb/taxon/neat_pdf/NEAT*Annelida.pdf].

Volcanic Iceland has approximately a 18 lumbricids, all introduced; and about 8 of the same species are known from glaciated Greenland (and Disko Island), as summarized by Omodeo (1957) and Blakemore (2006; 2007). Faeroes or Faroe Islands have about 11 species : *Allolobophora caliginosa, A. rosea, Dendrobaena octaedra, Dendrodrilus rubidus, Eisenia fetida, Eiseniella tetraedra, Lumbricus castaneus, L. rubellus, L. terrestris, Octolasium cyaneum, O. lacteum* (modified from Richard Pokorný pers. comm. Sept. 2016).

Few surveys are available from the Middle East, although El-Duweini & Ghabbour (1965; 2009) lists some Egyptian worms and Pavlicek *et al.* (2003) have 34 taxa from the Mediterranean Lavant region tomas-pavlicek-biologie.net/pages/earthworms_e.php; and 24 from Israel earthworms.elte.hu/Israel/israel1.htm. Omodeo *et al.* (2003) list all known megadrile fauna of the Maghreb. Omrani *et al*. (2005) catalogue 8 spp from Iran. Ghabbour (2009) notes six or seven Libiyan species and provided the table (his Tab. 1 from Marinoo *et al*., 2008) to 26 common sub-Saharan species. Recently, Szederjesi *et al.* (2013) reported on the 20 earthworms from Jordan as shown in their table following:-

Table 1. Updated list of earthworm species recorded from Jordan.

Name	Source of data	Comments
Aporrectodea caliginosa (Savigny, 1826)	1, 2, 3	Introduced in Jordan
Ap. jassyensis Michaelsen, 1891	1, 2	Possibly autochthonous in Jordan
Ap. rosea (Savigny, 1826)	2, 3, 4	Introduced in Jordan
Bimastos parvus (Eisen, 1874)	3	Introduced in Jordan
Dendrobaena alexandrii sp. n.	3, 4	Autochthonous in Jordan
Dendrobaena byblica (Rosa, 1893)	2, 4	Autochthonous in Jordan
D. negevis Csuzdi et Pavlíček, 1999	3, 4	Autochthonous in Jordan
D. orientalis karak Csuzdi et Pavlíček, 2005	2	Autochthonous in Jordan
D. semitica (Rosa, 1893)	1, 2, 3, 4	Autochthonous in Jordan
D. transjordanica sp. n.	new record	Autochthonous in Jordan
D. veneta veneta (Rosa, 1886)	2, 3, 4	Possibly autochthonous in Jordan
Eisenia fetida (Savigny, 1826)	2	Introduced in Jordan
Eiseniella neapolitana (Örley, 1855)	1, 2, 4	Autochthonous in Jordan
Eis. tetraedra (Savigny, 1826)	2, 4	Introduced in Jordan
Healyella syriaca (Rosa, 1893)	new record	Autochthonous in Jordan
Helodrilus patriarchalis (Rosa 1893)	1, 2, 4	Autochthonous in Jordan
Metaphire californica (Kinberg, 1867)	3	Introduced in Jordan
Microscolex dubius (Fletcher, 1887)	2, 3	Introduced in Jordan
Ocnerodrilus occidentalis Eisen, 1878	2	Introduced in Jordan
Octodrilus transpadanus (Rosa, 1884)	2, 4	Possibly autochthonous in Jordan

1 = Rosa 1893; 2 = Csuzdi & Pavlíček 2005; 3 = Pavlíček & Csuzdi 2006; 4 = present paper

Sims (1971) lists just four species from Diego Garcia Islands: *Amynthas rodericensis*, *Lampito mauritii*, *Metaphire morrisi* and unidentified *Dichogaster* sp.

For the 'New World' of the Americas, Blakemore (2005; 2006; 2007) has reviewed 182 species from the whole of North America (USA + Canada) – from the Arctic Ocean south to the Rio Grande but excluding offshore islands – based on reports such as those by Gates (1942) who for all North America checklisted more than 200 species [cf. Edwards & Lofty (1977) who provided a checklist of about 140 North American taxa (with 45 introduced species)] that was expanded (e.g. Reynolds, 1977, Fender & McKey-Fender,1990; McKey-Fender *et al.*, 1994). Compare to a claim by Reynolds & Wetzel (2004) of just 161 terrestrial oligochaete species in 10 megadrile families from the same region, including 45 exotics for which several of the names quoted are incorrect or have been superceded for quite some time (e.g. *Eisenia foetida* Savigny, 1826, *Amynthas hawayanus*, *A. diffringens* – see: http://www.inhs.uiuc.edu/~mjwetzel/TerrWoi.mjw.list.html May, 2005; Dec. 2008). In an earlier paper, Reynolds (1995) cited a checklist by Reynolds & Wetzel (1994) of 147 species from America north of the Rio Grande with 30-40% exotic. In the same volume, Fender (1995) estimated that the number of native North American species could be doubled, but that it would take 5 years full time-work to describe the 100 or so species and the results would be too big for conventional publication. Olsen (1936) described 17 earthworms from the State of Missouri; and Olsen (1940) the species from New York.

In Central, South America, and the Caribbean: Cognetti (1906) reviews all taxa then known. Blakemore (2005; 2007) lists 104 taxa from Mexico cf. Fragoso's (2001) list of 93 Mexican species (50% exotic cf. http://www.ujat.mx/publicaciones/uciencia/diciembre2005/LOMBRICES_art3.pdf). Righi (e.g. Righi, 1999) had covered Brazil and Mischis (2004 http://www.efn.uncor.edu/dep/divbioeco/DivAni1/lombric/lombr_arg.htm) gave totals of about 77 Argentinian species, some Chilean species were compiled by Sielfeld (2002 http://www.unap.cl/csmar/BioDiv1_archivos/ANNELIDA%20(Oligochaeta).pdf) and by Zicsi (2004). Blakemore (2005, 2007) has compiled updated taxonomic checklists of Annelids (megadriles) of the Southern Ocean, Argentina, Chile, and central Amazonia (e.g. much of Peru and Brazil) based on various publications, largely of the late Gilberto Righi (e.g. Righi, 1995), and from Lavelle & Lapied (2003) who listed 105 species including 10 peregrines [Ref]. Borges (2004) treats numerous Caribbean species, estimated to be 120 species with 25 exotic. Colombian totals based on Feijoo *et al.*

(2004) comprised 113 species in nine families, 30 genera and six subgenera, of which 90 are native and 23 exotic [http://www.ecologia.edu.mx/azm/documentos/20_2/M-Feijoo.pdf]. However, this list refers to some unpublished taxa and synonyms of *D. rubida*, *A. rosea* and *O. occidentalis* and overlooks *Pontodrilus litoralis*, so actual totals of known exotics differ. Guadeloupe species are reviewed by Csuzdi & Pavlicek (2009).

Most recently, ca. 830 known + 150 new Latin America taxa, totals were obtained from the second ELAETAO — the Latin-American Meetings on Oligochaeta Ecology & Taxonomy (Brown & Fragoso, 2007). Previously, Brown *et al.* (2006, ISEE8 conference abstracts) had made these Latin American totals (including about an estimated 100 undescribed/unpublised species which probably should be ignored):

"*Brazil (306 spp., 260 natives), Ecuador (136 spp., 113 natives), Mexico (133 spp., 83 natives) and Colombia (116 spp., 93 natives)*."

Two families seem to be endemic to Latin America: Exxidae and Tumakidae

Regarding Latin America, Fragoso *et al.* (2003: 400-404) and see http://www.cnpso.embrapa.br/elaetao/e01.htm (May, 2005) state:

"*Dr. Gilberto Righi (from the University of São Paulo) affirmed the existence of 240-260 oligochaete species in Brazil, 300-320 in Latin America and 320-350 in the Neotropics. However, he estimated a much greater diversity for Brazil (800 sp.), the continent (1600 sp.), and the Neotropics (2000 sp.), since there are still many areas with various habitats (soils, vegetation, climate, etc.) that have never been sampled, and where endemicity may be important..*"

...Similar statements could equally apply to the other biogeographic regions.

Rates of spread of introduced earthworms

Of great advantage when using whole organisms, such as earthworms, rather than abiotic remedies, for soil restoration and rehabilitation is that if the correct species are encouraged or (re-)introduced they will naturally multiply and spread. Ensuring that soil conditions are conducive for survival will result in natural colonization. Most species have only a limited range of activity, for example: endemic megadriles in North America have not generally expanded to occupy lands cleared by Pleistocene glaciation (and presumably they were not transported by Agricultural societies that lacked domesticated stock), and no native megascolecid in Tasmania is known to occupy even the whole of that small island state (Blakemore, 2000). Yet some surface wanderers may travel further, e.g. *Fletcherodrilus unicus* occurs throughout the length of Queensland and well into NSW (e.g. Blakemore, 1994 reports specimens wandering on the surface in Qld), and the Victorian native *Anisochaeta dorsalis* (Fletcher, 1887), once introduced into Tasmania, is now widespread (see Blakemore, 2000a,b, and again I have found specimens wandering on the surface one morning). An often quoted rate of spread of up to 10m yr^{-1} for introduced lumbricids (e.g. Hamblyn & Dingwall, 1945; vanRhee, 1969; Hoogerkamp et al., 1983; Stockdill, 1966, 1982; Stein *et al.* 1992) may be too conservative for some species. For instance, Mather & Christensen (1988) report that *Lumbricus terrestris* migrated up to 19m in one night, and Blakemore (1999:185) identified several lumbricids at least 20m from their possible source, stranded on an asphalt carpark early one morning after overnight rain in Tasmania. The species were *Aporrectodea caliginosa*, *A. rosea*, *A. trapezoides*, and *Octolasion cyaneum* – these were away from a drain where *Microscolex dubius* and *M. phosphoreus* (as new species records!) were also found (see Blakemore, 2000a; b).

There is a need to differentiate between rates of active dispersal and passive dispersal or transportation by other agencies such as fluvial, bird or animal migrations (supposedly with cocoons attached) and the movement of soils attached to goods, plant stock and machinery by humans (Schwert & Dance, 1979; Lee, 1987, 1985; Schwert, 1990: 345; Marinissen & van den Bosch, 1992; see also recent papers from Canadian province of Alberta Ref1, Ref2).

Cocoons and other life stages assisted by human activities can spread rapidly, e.g. carried with soil in plant pots, ships' ballast, water stores or cargo, bait boxes, and potentially even attached to tools, wheels or boots – thus earthworms may follow (sometimes literally!) in the footsteps of travellers. In Australia, just 100 years after

European settlement, Fletcher (1887: 375, 1890) recounts how lumbricid "interlopers" were found in almost every locality of the colony of NSW whence he obtained earthworms, as well as in Victoria and Adelaide - a rate of spread, discounting the trans-oceanic component, equivalent to >10 km yr^{-1}. Fletcher (1886a: 524) also reported letters in *Nature* (1884: 213, 406, 503) saying that earthworms did not originally exist in the prairies of the Canadian North-West nor parts of the United States ("*Kansas, Idaho, and the Indian and Washington Territories*"):

"*until settlement and tillage by man there is no trace of earthworms even in those most favourable localities called 'beaver meadows'... At first they are found about the stable-yard, then in portions of ground enriched by stable manure, garden or meadow, till at length they may be found in all soils, either those cultivated or those pastured by domesticated animals*."

Introduced species now inhabit every state or province of the United States and Canada (Schwert, 1990). Initial modes of introduction are supposed to be primarily with shipping of plants between countries (Gates, 1958;1976). Gates (1958: 2, 19) attributes spread of some species to gardners, horticulturalists, turf farmers, transport of earth-moving machines, worm culturalists and anglers.

Lee (1987: 317) - citing Smith (1893) from New Zealand and Lindroth (1957) from North America, allowed that soil used as ballast in ships could be regarded as a further source of terrestrial worms, as was noted early on by American botanists on the arrival of Old World plants that came to be known as "*ballast waifs*" arriving at ballast grounds [e.g., Smith (1867) "On colonies of plants observed near Philadelphia". *Proc. Acad. Nat. Sci. Phila.* 19: 15-24; and Brown (1878) "Plants introduced with ballast and on made land". *Bull. Torrey Bot. Club* 6: 255-258].

However, dispersal of some peregrine species predates the movement of European explorers and traders reflecting earlier, undocumented wanderings and commerce within the Pacific and Indian Oceans. Stephenson (1931: 35) speculated that ancestors of the small species of *Dichogaster* "*have probably been carried eastwards from Africa in successive stages, perhaps accidentally by early man in his wanderings, in his belongings, or later in merchandise of one sort or another*". Distributions of pheretimoids such as *Pheretima*, *Begemius*, and *Polypheretima* which are indigenous to New Guinea and south-east Asia, may provide further evidence of such human movements. Introductions of other species such as the lumbricid *Eisenia japonica* into Japan may have coincided with colonization by earlier human occupants, for example

the Ainu people from Siberia. Europeans, perhaps starting with the Norse and Vikings (e.g. Gates, 1972: 90), have been responsible for the global transportation of earthworms to the New World and Asia only in the last 1,000 years. And about 500 years ago regular exchange between Europe, Africa and South America commenced (the so-called triangular trade routes including slaves) which may account for the distributions of certain octochaetid species in West Africa and Central and South America. Prior to this there have been Indonesian, Indian, Arab and Chinese seafarers and traders in the Indian Ocean; and Polynesian and Melanesian peoples, for at least the last 3,000 years, have migrated in the Pacific carrying with them food plants (Lee, 1981: 570; 1987: 317). Thus, species of *Rhododrilus* (?and *Octochaetus*) may be introduced into Australia providing some evidence of a New Zealand connection. What contact and trade occurred in ancient times is not well known, certainly there has been a long period of human settlement in Australia, possibly extending back between 60,000 to 120,000 years ago (e.g. Singh *et al*, 1981; Singh & Geissler, 1985; Wright, 1986). But often details are speculative and there are more questions than answers - for several earthworm species even their place of origin is obscured by frequent transportation, although such questions may now be resolved genetically.

Ecological strategies

Earthworms' ecological strategies are functions of their behaviour, morphology, physiology, phenology, demography, and habitat, and have been categorized by various authors - most notably by Lee (1959, 1985, 1987), Laverack (1963) and, subsequently and independently, by Bouché (1971, 1972, 1977) that was extended by Lavelle (1983). They can change with changing life stage (e.g. Kobel-Lamparski & Lamparski, 1986/7 description of ecology of *Lumbricus badensis* Michaelsen, 1907). Based on broad eco-taxonomic studies of New Zealand earthworms, Lee (1959: 418) proposed readily interpretable categories that are applicable to most earthworms (e.g. from families Acanthodrilidae, Octochaetidae, Megascolecidae, Lumbricidae, etc.), although these may change with the life-stage of the worm; these were:

Terrestrial
- soil, including leaf mould (humus)
- under logs and stones on soil surface
- under the bark of dead trees; in rotting logs
- in decaying plant remains in the axils of branches of forest trees

Aquatic
in the mud and under stones of stream, pond and lake bottoms
in the water of deep lakes
in swamps
in the intertidal zone on sea shores and adjacent brackish water

Lee (1959) argued that the most successful habitat was soil with major categories:

1. **Litter (or leaf mould) species** – that live and feed in the rich litter layers on the soil surface and are subjected to greater environmental fluctuations and to greater predation.
2. **Topsoil species** – maintain burrowing in the A-horizon, only occasionally coming to the surface to feed (or mate).
3. **Subsoil species** – dwelling entirely underground in extensive burrows in the B and/or C horizons of the soil and feeding in the lower root zones.

The Massey University, NZ website has a summary of Lee's groups [http://soilbugs.massey.ac.nz/oligochaeta.php]. Presumably the subsoil species breed entirely underground although some may also provide the irregularly observed phenomenon of 'mass migration' where numbers of sometime quite large species are observed on the surface under suitable conditions.

Meanwhile, Gates (1961) classified lumbricids in Maine, USA into ecological groups based on their seasonal activity, habitat and diet:

1. *Geophagous* - feeding mainly on soil.
2. *Limicolous* (or *limiphagous*) - in mud or saturated soils.
3. *Litter feeders* - in leaf litter, compost or manure.

Bouché's (1971, 1977) subsequent scheme, most applicable to just a few French lumbricids, was:

1. **Epigeés –** living and feeding on the soil surface; (the term "epigaeic" or "epigeic" is actually adopted from plant and other invertebrate glossaries, the alternative strategy perhaps being "hypogaeic" or "hypogeic").
2. **Anéciques** – relatively rare situation where a worm burrows into the soil (in A to C horizons) but feeds at the surface (from Greek meaning to "reach up").
3. **Endogées** – live in the mineral horizons, feeding on organic matter in the soil, with sub-categories depending on depth of working.

The terms "*epigeic*" (or epigean or epigaen or epigenous) - meaning living at or above the soil surface, and "*endogeic*" (or euedaphic or hypogeic) - meaning

interstitial soil dwellers, are also used in a similar way by some other branches of soil ecology; whereas "*anecic*", from Greek *anekas* meaning upwards (reaching), appears to be used only for deep burrowing earthworms that come to the surface to feed or breed. [Strictly, and organism is **epigean**, **epigeic** or **epigeous** if it crawls (epigean), creeps like a vine (epigeal), or grows (epigeous) on the soil surface].

Two of the classificatory schemes above are essentially complementary in their parameters, differing slightly in interpretation, although Lee's prior terms take precedence and largely encompass the equivalent French terms and have the added advantage of avoiding technical terms that are obscure and thwart general understanding. Sims & Gerard (1985; 1999: 29-30) and Coleman & Crossley (1996; 2003: 104, Tab. 4.6) list Lee's terms (with Bouché's equivalents appended or in braces). More recently, Kladivko (1997) followed Lee (1985) by dividing worms into three major behavioral classes: "*litter-dwellers*", "*shallow soil dwellers*" and the "*deep-burrowers*" [Kladivko, E.J. (1997). Earthworms and Crop Management. http://www.ces.purdue.edu/extmedia/AY/AY-279.html]. Lee's categories encompass a wider repertoire of behaviours and habitats, for example species that are aquatic, arboreal, or littoral. However, several species appear to overlap categories or fail to comply with any, indicating a need for further classification.

Perel' (1977) had divided lumbricids into "*humus feeders*" and "*humus formers*" which corresponds closely with detritivores that feed directly on organic substrates, and geophages that feed on oganic matter incorporated in the soil. Whereas, Buckerfield (1994) greatly simplified classification of commonly encountered earthworms as either "*composters*" or "*fieldworkers*". Species used in vermiculture and vermicomposting are mostly derived from litter species and are classed as 'composters'; these species can be readily cultured in rich organic substrates but in general do not survive well in the field, and are not the same as the most beneficial of agricultural and horticultural 'fieldworkers'. Vermiculture and vermicomposting appear to be expanding industries; the success of this operation depends on selection of appropriate behavioural and ecological characteristics of stock and, as prerequisite, correct species identification. Lee (1985) and Edwards & Bohlen (1996) provide comprehensive reviews and discussion on the ecology of earthworms and their relationship with soils and land use.

For priority and practical purposes, I prefer to support Lee's (1959) ecological categories based on their soil horizon habitat, combined with Bouché's single term "anécique" for the very few species, such as *Lumbricus terrestris*, *Eophila tellinii* (Rosa,

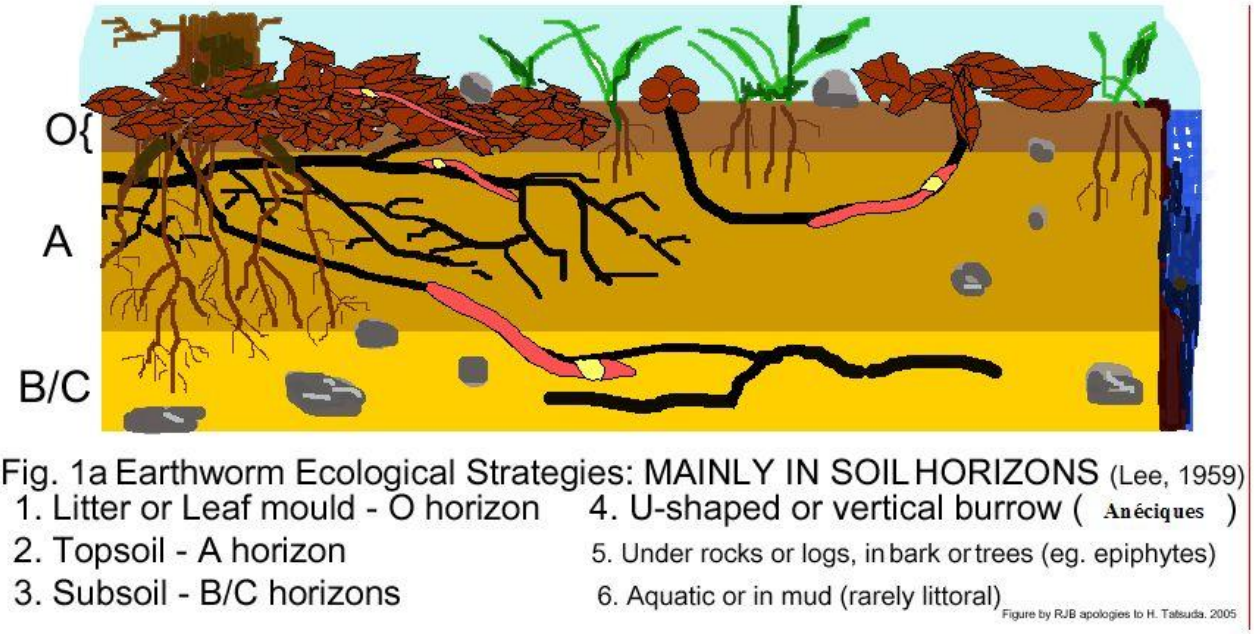
1888), or *Amynthas yambaruensis*, that maintain (semi-?)permanent vertical or U-shaped burrows allowing them to feed on litter at the surface.

Based on all the accumulated information above, following a Principle of Scientific Priority of publication, and in order to avoid unnecessary jargon in Science plus my personal interpretation of their behaviours, a reasonable summary of the major earthworm Ecological Strategies now is:

1. **Litter species** now including "*composting worms*" such as *Eisenia fetida**
2. **Topsoil species**, often the "*fieldworking worms*" such as *A. caliginosa*
3. **Subsoil species** living and feeding mainly in the deeper mineral layers of soil that are more difficult to sample, e.g. in Australia *Megascolides australis* McCoy and *Notoscolex grandis* Fletcher, 1886
4. **Anecic species** such as *Lumbricus terrestris, L. badensis, L. polyphemus*, *Fitzingeria platyura* (Fitzinger, 1833) sub-spp, *Amynthas yambaruensis* (only adults?), *Megascolex filiciseta* Stephenson, 1915 and possibly African *Millsonia inermis* (Michaelsen, 1892) (as redescribed here)**.**

*Possibly the few vermicomposting species should have their own separate group.

Schematics of Earthworm Ecological Strategies – Figured below (Fig. 0.8).


O{
A
B/C
Fig. 1a Earthworm Ecological Strategies: MAINLY IN SOIL HORIZONS (Lee, 1959)
1. Litter or Leaf mould - O horizon
2. Topsoil - A horizon
3. Subsoil - B/C horizons
4. U-shaped or vertical burrow (Anéciques)
5. Under rocks or logs, in bark or trees (eg. epiphytes)
6. Aquatic or in mud (rarely littoral)
Figure by RJB apologies to H. Tatsuda. 2005

Some carvenicolous or troglodytic species are only found underground in caves whereas known terrestrial/aquatic species may occur there adventitiously.

Behavioural responses

Laverack (1963: 171) provides a physiological background on earthworm behavour. The ecological requirements of particular species may be derived from survey and ecological observation, alternatively behavioural choice trials can be conducted for selective assessment with various combinations of soil and amendments in mesh cages arranged like slices of a pie (Blakemore, 1981; 1994; 2000 and Fig. 0.9). Using a very similar design, Canadian ESG International, Inc. later developed an avoidance-response ecotoxological test of earthworms in contaminated soils that is scheduled to become a new international method by the ISO 190 (Soil Quality) [Ref.].

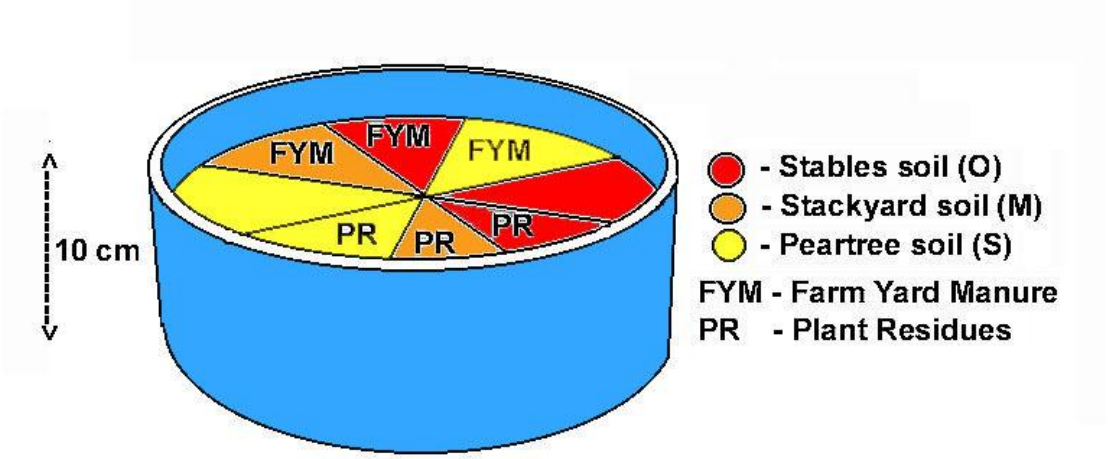


Figure 0.9. **Choice chamber** diagramatic from Blakemore (1981; 2000) using wire and plastic/nylon mesh wedges to hold soils that could quickly be removed, like pie slices, to determine migrations of earthworms introduced to the centre. O – Organic;m – Mixed (partly organic partly intensive/conventional), S – Standard conventional.

Such laboratory experiments can rapidly determine selection preferences of several species of earthworms by offering them a choice of substrate and recording their movement, preferences are indicated by the aggregations of freely-moving earthworms. Determining the requirements of earthworms helps to define culturing conditions, indicate their potential to colonise new habitats and to explain their distributions. Soil type, food supply, moisture and temperature are important limiting factors that can be divided into two broad categories, matrix (soil and food) and environment (temperature and moisture). The first category can be investigated using choice chambers, and the second by (horizontal) gradient columns. Most reported studies (e.g. Svendsen, 1957; Westernacher & Graff, 1987 and others listed in Lee, 1985)

have related distributions of earthworm as indicated by surveys with environmental factors, a few have involved laboratory growth trials, but rarely have behavioural choice trials been attempted. As each species is unique, a combination of different permutations can be progressively tested and refined by use of such trials to gauge precise requirements. Other experiments can be devised to determine how sighless earthworm find their food and a mate – as far as I can discover this is a unresearched open.

Temperature and moisture tolerances

Major constraints on earthworm breeding and survival are matrix (soil texture and food supply) and environment (temperature and moisture). Required conditions for a species can be estimated by field observation or, more rapidly, in the laboratory with choice trials. Experimental choice trials in sections or in horizontal plastic tubes with soil temperature/moisture gradients – as used by Blakemore (1981, 1994) – can determine optima (see also Lee, 1985; Lavelle, 1988). Other laboratory determinations of temperature and moisture preferences have used differentially wetted towers of soil and recorded migrations (e.g. by Grant, 1955a, 1955b; Madge, 1969; Daugbjerg, 1988; Lavelle *et al*., 1987). However most studies failed to account for the vertical burrowing response normal to most species and would be better layed with the columns horizontal.

In Nature, perhaps the highest temperatures tolerated are by *Acanthodrilus kermadecensis* Lee, 1953 which was collected from steaming soil, almost too hot to handle, at the mouth of a fumarole in the main crater on Raoul Island, and *Eisenia fetida* was also recorded nearby (Lee, 1953: 49); this latter species was also found at a hot spring in Iceland (Backlund, 1949). Gates (1967) reports on desert species, with some lumbricids from hot sulphur springs.

Lower temperatures are habitable for several species that acclimatize to survive under ice or snow; e.g. Lee (1985: 44) reports Ghilarov's claim that *Eisenia nordenskioldi* revives after long periods of being frozen, with freeze tolerance down to -30°C recorded for *E. nordenskioldi* (subspecies?) by Holmstrup & Petersen (1997) and Berman & Leirikh (1985). Michaelsen (1929) had found it at thermal springs in Kamchatka and Berman et al. (2002) further report on adaptation to arid conditions. Its sibling species, *Eisenia fetida*, common at altitude in the Himalayas (Stephenson 1925), may be found in Svalbad/Spitzbergen or Siberia wandering on or under snow (some reports possibly misidentifications of *E. nordenskioldi*?); it is also found in deserts (e.g. of Arizona by Gates, 1967) and Csuzdi & Pavlicek (2005a, b) report it

from Mar Saba and Samaria, Israel and Jordan. *E. fetida* was further located at hot springs on subarctic Iceland and a fumarole at subtropical Raoul Island, N.Z. (as noted above); its experimental temperature range is given as -2° to +40°C (Lee 1985: tab. 2) and is reported to survive total water immersion for periods up to 6 months (Gates, 1972: 100). *Perionyx excavatus* seems to be equally at home in tropical lowlands and in the Himalayas at altitudes of 3,000m (Gates, 1972: 142). Recent studies by Berman & Leirikh (1985), Holmstrup & Petersen (1997), and Berman *et al.* (2001) summarize the freeze tolerance in *E. nordenskioldi* and *Dendrobaena octaedra*. Incredibly, Berman *et al.* (2012) found that cocoons of *Dendrodrilus rubidus tenuis* withstand 24-hr exposure to temperature of liquid nitrogen (-196ºC) with 50% survival rate, but after hatching worms at any age failed to survive even insignificant exposure to cold (e.g. -1 – -3ºC). Vermicomposter *Eudrilus eugeniae* is sensitive to <40°F (4°C)C at which time the worms die and fail to reproduce (as reported below).

Although most species may be confined within particular climatic zones, the most widespread peregrines tend to have broader temperature and moisture tolerances.

Interestingly, Blakemore (1981, 2000) found that earthworm abundance corresponed both to increased soil moisture and ameliorated **soil temperature** in adjacent fields subject to different fertilizer regimes, i.e., organic vs. conventional.

Earthworm Effects on Soil Processes

Introduction. The importance of soil fauna to pedogenesis and plant production was known at the time of Darwin (1881). Only slowly, and through much subsequent research, are the energy and nutrient dynamics, the trophic relationships and the interactions between the various elements being elucidated. Perhaps six of the most important functions attributed to soil biota are:

1. regulation of nutrient cycling processes
2. maintenance of soil structure
3. direct interactions with plants
4. indirect interactions with plants via microbial stimulation
5. as ‘bioindicator’ species for the (ecotoxicological) health of the soil ecosystem
6. as a ‘bioprospecting’ resource for new molecular or pharmaceutical products (especially since soil is the ultimate venue and sink for all biotic interactions).

Earthworms, as major components of the soil macrofauna and as potential restorative

agents, have significance in all these processes and roles, either directly (e.g. by working the soil) or indirectly (e.g. by influencing microorganisms, or when affected by poisons). The issues of soil physical properties, chemical fluxes, soil formation, plant production and decomposition, and soil biotic processes are all interrelated. The mechanisms and magnitudes of the contribution of earthworms are considered here. Reviews may be found in Edwards & Bohlen (1996), Lee (1985), and only the most salient points, or research subsequent to these reviews, is presented in this critique.

Nutrient cycling. Just as the fertility of a soil influences its carrying capacity for earthworms, so are earthworms important regulators of the qualitative and quantitative supply of plant nutrients, especially Nitrogen (N) and Phosphorus (P). Moreover, as biotic entities, the activities of earthworms are in synchrony with those of plants and are at the site of most nutrient exchange: in the rhizosphere (root zone).

Balfour (1977), on the 'Haughley Experiment' (see Blakemore, 1981; 2000), said:

> "*It was clear, from the fact of the closed cycle, that this seasonal release of minerals could only have been brought about by biological agencies, and it appears to be a natural action-pattern of a biologically active soil.*"

Some enlightening farm plant nutrient in soil data from Haughley fields is presented here. Many subsequent investigations are found into the complex interactions and roles of earthworms in nutrient cycling (summarised in Lee, 1989; Lee & Pankhurst, 1992; Adl, 2003). The main source of nutrients for earthworms is the 'fast' cycling component of recent organic matter (Coleman *et al.*, 1983), especially that liberated by saprophytic fungi and bacteria; soil mineralogical nutrients are a lesser source, even for geophagous earthworms, while inorganic fertilizers added to agricultural soils are either a benefit, through increasing plant organic matter production, or a hazard where they increase acidity (Howard, 1945; Springett, 1985; Lee & Ladd, 1984; Lee, 1985; Lavelle, 1988; Blakemore, 2000).

Cycling of nitrogen, the most abundant of the nutrients, is generally well researched, but perhaps still not fully understood. It has been estimated that earthworms may be responsible for processing up to 100-150 kg ha^{-1} of N yr^{-1} in some environments (Keogh, 1979; Lee, 1985). The main processes involved are:

- excretion of NH_4 and urea - up to 50 kg ha^{-1} of N yr^{-1} (Lee, 1989);
- secretion of mucoproteins from the epidermis and gut - up to 50t ha^{-1} yr^{-1} of mucus

containing 3% N for a species in Mexico (Lavelle, 1988);

- casting - casts often have 1.5-5.0 times concentrations of NH_4-N (Lee, 1985; Lavelle *et al.*, 1992);
- mortality - bodies (dry mass) contain about 80% protein (12% N), death may release 9-75 kg ha^{-1} of N yr^{-1} (Christensen, 1988; Lee, 1989);
- stimulation of nitrogen metabolising microbes either symbiotically or synergistically (Lee & Pankhurst, 1992);
- increasing N leachates - up to 60-fold for NH_4-N and 10-fold for NO_3-N (Anderson *et al.*, 1983).

Phosphorus (P) and sulphur (S) cycles are also important but the processes are not as well understood (Lee, 1985; 1989). Fresh worm casts often have higher P levels, in the order of five to ten times compared to soils, and the proportions of N:P:S in body proteins are about 12:1:1 (Lee, 1989). The next three studies, all from New Zealand, illustrate these points: Syers & Springett (1984) estimated that in pastures, annual inputs from earthworms would increase nutrient totals by up to 42 kg ha^{-1} for N and 9 kg ha^{-1} for P and S. Mansell *et al.* (1981) presented evidence that earthworms increase the short-term plant availability of P, derived from plant litter, by 2-3 fold. Subsequently, Basker *et al.* (1992) recorded increased available potassium (K) in soil in 'petridishes' - equivalent to 31.8 kg ha^{-1}, after 21 days of earthworm activity.

According to Lee (1985), earthworms are relatively minor contributors to carbon (C) assimilation and energy flow in temperate ecosystems although in N.Z. pasture, annual C flux increases from 300 to 1,000 kg ha^{-1} have been estimated when worms were introduced (O'Brien & Stout, 1978) and Yu *et al*. (2007) suggested that earthworms might alter the transfer of plant photosynthates from the aboveground to the belowground, and thus, soil active C pool. In tropical systems, assimilation of 10-15% of gross annual primary production may be attributed to earthworm activity (Lavelle, 1974). In US forests that were formerly uncolonized by earthworms, their activity has been found to help sequester C: a Purdue university research team found that forests with greater numbers of invasive earthworms tend to have litter and soil organic matter enriched in the plant material lignin, which is typically harder for bacteria to decompose; whereas sites with low numbers of these earthworms accumulate plant carbon in forms more easily degraded (Ref.; Ref.). Considerable differences in accumulation (or rather reduction of loss) of Carbon sequestered in Soil Organic Matter

(**SOM**) under different agricultural regimes and as affected by soil fauna can be compared (e.g. Blakemore, 2000; Sumner, 2000; Adl, 2003; Ref., 2007).

Carbon in soils is greater than that sequestered in forests or Oceans combined. Based on work by Dr Christine Jones (Jones 2006) one of Australia's leading experts on carbon sequestration:

"Every tonne of carbon lost from soil adds 3.67 tonnes of carbon dioxide (CO2) gas to the atmosphere. Conversely, every one tonne increase in soil organic carbon represents 3.67 tonnes of CO2 sequestered from the atmosphere and removed from the greenhouse equation.' ... 'For example, ***a 1% increase in organic carbon in the top 20 cm of soil with a bulk density of 1.2 g/cm3 represents a 24 t/ha increase in soil OC*** *which equates to 88 t/ha of CO2 sequestered."* Climate resolved!

Water/temperature relationships. Through modification of their environment, earthworms gain the double benefits of better moisture retention and greater food supply via enhanced plant growth. Improved soil moisture relations are perhaps the most direct and significant effects of earthworm activity, particularly where water is limiting. Other, interrelated considerations are that greater through-soil movement of water may increase nutrient solution and leaching, but decrease waterlogging and erosion due to runoff. Burrow channels allow greater entry of water may also provide better root access to moisture and nutrients at depth although increased plant vigour increases water demand.

In the early experiments of Hopp & Slater (1948), infiltration rates increased 2.7-4.6 times in barrels inoculated with living worms, but not where surface litter was removed. Similar trials by Guild (1955) were accompanied by waterlogging in soils unworked by worms. In Australia, Abbott & Parker (1980) found that presence of an exotic species (*Microscolex dubius*) in combination with clover mulch doubled infiltration rates in small pots. Blakemore (1981, 2000, 2018) correlated eathworms and soil moisture under different management regimes in adjacent fields measured on same days.

Many other field investigations have demonstrated that earthworms increase water holding capacity of soils and hence soil stability and plant growth. In particular, the effects of various cultivation practices have been compared. Ehlers (1975) in Germany compared tilled and zero-tilled corn fields finding more worm burrows and infiltration rates about 6 times greater in the latter. Lal (1974) made comparisons in similar situations in Nigeria, where eudrilids are common, and found about 24 times the numbers of worm casts and infiltration rates almost doubled under zero-till plots. Also in Nigeria, Wilkinson (1975) showed a positive relationship between infiltration rates

and earthworms in fallow, and Aina (1984) confirmed a 2.5 times increase in infiltrability due to earthworms in forest soils. A correlation between infiltration and earthworm biomass was also presented by Stewart *et al.* (1988) for a study in the U.K. These latter workers advocated farming initially for the "*benefit of the earthworms*" when utilising degraded land. This was exemplified in a study by Clements *et al.* (1991) where elimination of earthworms by 20 years of deliberate biocide (and fertilizer) overuse in a pasture, led to reduced infiltration rates and lower soil moisture (by ~ 6%).

New Zealand studies reported that pastures with introduced lumbricids had, compared to pastures without earthworms, a 17% greater moisture capacity, doubled infiltration rates and half the surface run-off (Stockdill, 1966; Stockdill & Cossens 1966; Stockdill, 1969; Sharpley *et al.* 1979; Stockdill 1982). Adding a deep-burrowing species to a similar earthworm-occupied soils resulted in additional soil moisture of about 4% and almost doubled infiltration again (Springett, 1985).

In orchard soils, van Rhee (1969) demonstrated an increase of 10.8% in the moisture available for plants, when earthworms were present. An Australian study by Tisdall (1978) reported a very high lumbricid population in a non-cultivated, heavily mulched and irrigated orchard not subject to heavy biocide applications. This population was associated with a much higher soil porosity and infiltration rate. A later study (Tisdall, 1985) found relationships between management techniques and earthworms, and earthworms and porosity/infiltration: irrigation, non-cultivation and pasture rotations produced most beneficial values. Blakemore (1994) also found infiltration rates up to 24% higher in soil cores with certain species, but not with other species nor in the field.

Blakemore (1981, 2000) reported soil moisture differences related to earthworm populations under different farm management regimes (organic vs. conventional), highly significant was a associated difference in **soil temperature** too during winter months. Blakemore (2018) shows organic management maintains earthworms and higher SOM with soil moisture about 30% higher than in chemical/conventional farm management. Assuming an average bulk density of 1.0 g cm^{-3}, this gives equivalent (Ref.) to 30% extra rainfall! The formular for extra soil equivalent in rainfall is: % change volumetric water content = % x BD = mm of water per 100 mm depth or rainfall equivalent.

Soil structure. Soil structure and soil biota are interdependent: well structured soil, which develops in response to biotic and abiotic (e.g. mineralogical and weathering) factors, has greater scope and diversity of microhabitats. Earthworm distribution relies

partly on the texture of soil, while the activity of earthworms modifies their environment, particularly the soil structure. The main mechanisms involved are burrowing and casting which permeate, mix and bind soil. Experiments have shown that degraded soils with earthworms alone, or in combination with plants, can decrease bulk density and increase both porosity and structural stability (e.g. McColl *et al.*, 1982; Aina, 1984; Shaw & Pawluk, 1986; Stewart *et al.* 1988; Springett *et al.*, 1992; Zhang & Schrader, 1993). The opposite effect, the deterioration of soils from which worms have been deliberately excluded, has also been recognised (e.g. Clements *et al.*, 1991). Occasionally, earthworm activity has a negative effect on soil structure through excessive mixing leading to compaction and erosion (Lee, 1985); yet this mixing of soils and preferential ingestion and deposition of smaller particles may contribute to the formation of soil profiles (e.g. Darwin, 1881; Lee, 1985; Lavelle, 1988). Mixing also improves incorporation of surface applied treatments, such as lime, fertilizers and biocides (Stockdill, 1966; MacKay *et al.*, 1982).

The magnitude of physical effects depends on the existing structures of soil, the composition of the earthworm community and on the interval of observations (Brusaard & Koistra, 1993). Some examples of the contribution to soil structural characters are:

- bulk density increases 12-19% in 20 yrs without worms (Clements *et al.*, 1991)
- porosity related to burrows of 5% total soil volume (Edwards & Lofty, 1977)
- aeration increased by about 10-20% (Lee, 1985)
- water-stable aggregates >2.0 mm increased by 21-47% with earthworms (and plants), compared to controls after 2.5yr (Blanchart *et al.*, 1990; Blanchart, 1992)
- cast materials found to have greater structural stability than the surrounding soil (Lavelle, 1988; Lee & Pankhurst, 1992; Zhang & Schrader, 1993).

Worm casts. Considerable rates of deposition have been reported and several workers have also found casts to be enriched in plant available macronutrients and micronutrients, proteins and enzymes when compared to the soil matrix. Common estimates of annual productions of surface casts in temperate regions of 4-250t ha^{-1} are lower than some reports from the tropics, of ranges of about 60-600t ha^{-1} (Darwin, 1881; Edwards & Lofty, 1977; Lavelle, 1978; Lee, 1985; Lal, 1987). Highest estimates in the tropics, by Lavelle (1988) and Lavelle *et al.* (1989) are of over 1,000t ha^{-1} yr^{-1}. Surface casting varies with species, season and soil type, but the common ranges above represent

deposition of continuous layers of soil from about 0.2 to 2.0 mm thick annually (Darwin, 1881; Lavelle, 1988). Barley's (1956c) estimate of 2.5t ha^{-1} casting in pastures in South Australia is exceptionally low and may be seasonal. (Note: higher figures for cast production in the tropics of 2,100 and 2,600t ha^{-1} yr^{-1}, reported in Edwards & Lofty (1977: 144), are overcalculations from the original sources by a factor of ten!). It is pertinent that most earthworms work below ground where their casting may be many times greater (Lavelle, 1988). For example, Shipitalo *et al.* (1988) give maximum sub-surface adjusted casting rates in the order of 280-950t ha^{-1} yr^{-1}.

Lunt & Jacobson (1944) established that worm casts are enriched in N, P, K, Ca and Mg. Many subsequent studies have shown that secretion of $CaCO_3$ or NH_3 in the gut affects the pH of casts, which tend to neutrality, and that the amounts of exchangeable cations released in casts are often more than double the rates in the substrate (Lee, 1985). Most studies have involved lumbricids, relatively little is known about the cast compositions in other groups (cf. Barois, 1992).

Despite having higher nutrients, direct contribution of casts to improved plant growth may be moderate, for example, Mansell *et al*. (1981) detected only slight increases in yields with cast material when added at "*normal*" rates of application (equivalent to average casting rates from the field). Nevertheless, casts are used in India, the Philippines, Australia, China, USA, Cuba and Mexico at least (Ref1, Ref2, Ref3). Reddy (1988) tested the effects of vermicasts or vermicompost (the product, along with worm biomass, of vermicomposting operations) on growth of rice in pots: Rates were 310 g, 620 g, and 940g of casts per 2 kg soil (to give the equivalents to 20, 40 and 60 kg K_2O ha^{-1}) compared to soil only. Significant increases in plant growth were recorded after four months. Reddy surmised that the effects of the casts on the growth of rice may be due to the presence of "*plant growth substances*" identified by others as indole compounds also "*yield-influencing substances*" which could be secreted into the casts, and, in turn increase the plant growth. In addition, chemical analysis of casts showed that they were richer in various plant nutrients compared to the underlying soil. Also in India, Kale *et al.* (1992), found that when vermicompost was applied to a rice paddy as an organic fertiliser amendment, there were significant increases in the colonisation of soil by nitrogen-fixing bacteria and mycorrhizal fungi. Higher levels of total nitrogen in the plot with added vermicompost was attributed to higher populations of nitrogen-fixing bacteria. A report by Logsdon (1994) makes passing reference to a study in Pune, India (by H. Jambhekar from Matarasha Agricultural Bioteka) that grapes fertilized with 2 tons

of vermicompost per acre (ca. 5 t/ha) per year for five years increased yields to 15 tons per acre, higher than yields under conventional fertilization and there were additional improvements in soils.

Australian trials, reported by Buckerfield & Webster (1998a, 1999), using mulches of vermicompost derived from grape marc or pomace led to 300% increase in grape yields within six months.

Bahl (1934) discussed some casting habits and Howard (1945) also noted their importance in soils in the UK. The casts of some native and exotic species were characterized by Blakemore (1994: tab. 4.3.21) summarized in the table below:-

Table 4.3.21. Description of surface casts and soil matrices of dismantled cores.

Spp	Appearance of casts; soils
Drawida barwelli	in the field, matrix ramified with re-filled burrows suggesting sub-surface casting
Dichogaster affinis	fine granular casts (0.5-1.0mm); friable
Dichogaster saliens	often inhabiting small chimneys
Spenceriella (= *Anisochaeta*) *minor*	casts not obvious
Pontoscolex corethrurus	medium sized surface globular or ribbon casts especially when soil wet; soils permeated with burrows
Polypheretima elongata	large globular (30mm wide) and long threads; surface pitted and many large ramifying burrows (2-9mm wide)
Po. taprobanae	occasional surface casts
Eudrilus eugeniae	copious regular pellets 2-3x1mm especially around sides; burrows also along edges; roots grow up into casts
Aporrectodea trapezoides	extensive globular surface casts
Metaphire californica	patchy subrounded up-wellings
Fletcherodrilus unicus	distinctive elongate pellets 2-6x2mm
Eukkeria saltensis	fine granules
Digaster brunneus	none found; large diameter burrows

Species casting profusely on the surface were *Eu. eugeniae* in all three soils, and *Dichogaster spp.*, *Pont. corethrurus*, *Polypheretima elongata*, *A. trapezoides* and *M. californica* in either or both Narayen and Samford soils (Table 4.3.20). Species that appeared to cast mainly below ground were *Polypheretima elongata*, *S. minor*, *P. taprobanae* and *Dg. brunneus* (despite mortality of this latter species, several helical burrows were found in the cores on dismantling). Additional observations were that casts in the denser clay soils were more aggregated and water-stable than those in sand. Chemical analyses of samples of air-dried surface casts and topsoils for the Narayen clay and Samford sandy soils were presented in Blakemore (1994: tabs. 4.3.22 and 4.3.23). ”

Burrows and roots. Earthworm species vary in, and have been ecologically categorised according to, their burrowing and feeding strategies (Lee, 1959, 1985, 1987).

Burrow diameters may range from less than 1 mm to greater than 10 mm, are as extensive as 9,000 km ha^{-1} (Kretzchmar, 1982) and extend as deep as 15 m (Sims & Gerard, 1999: 27; Blakemore, 2000e). Therefore, they have profound implications not only for aeration and water conductivity but also for channelling of plant roots. Earthworms are able to exert considerable hydrostatic pressure when probing compacted soils (McKenzie & Dexter, 1988a, 1988b): Maximum axial pressure was 116.5 kPa, radials were around 230 kPa or approximately one-tenth of pressures recorded for plant roots. Radial pressures tend to be about twice axial for both worms and roots. In comparison, nematodes generate 2-30 kPa (Ref), and fungal mycelial turgor pressure is 400-1,800 kPa (Ref) (atmospheric pressure AMSL is about one bar or 100 kPa). Thus nematodes have about 10 kPa, earthworms ca, 100s kPa, roots & mycelia ca. 1,000s kPa. However, it is often reported that earthworms force their way through soil and do not consume it, which is quite mistaken from personal observation of surface casts after rain. Moreover the muscular pharynx equipped with a suction pad, and the strong, often multiple, gizzards allow considerable ingestion and comminutation of soil therefore the earthworm contribution may be substantially greater than small roots and mycelia.

Several researchers have noted root proliferation in burrows which they usually attribute to the combined effects of following paths of least resistance and of better access to nutrient and moisture gradients in the drilosphere (e.g. Edwards & Lofty, 1978, 1980; van Rhee, 1965, 1977; Ehlers *et al.*, 1983; Springett, 1985; Wang *et al.*, 1986; Parker, 1989; Dexter, 1991; Ruiz et al., 2015). These latter authors estimate earthworm burrows displace >100 kg m^{-2} per year compared with plant root displacemen of 1 kg m^{-2} per yr. Energy required by the earthworms to build their network of burrows was estimated at 0.05 kg yr^{-1} SOC per m^2 , equivalent to 15% of the annual NPP in crop lands.

Several aspects and examples of the effects of burrows on root growth are summarised in Logsdon & Linden (1992) who, nevertheless, argue that improved root growth does not always translate into increased crop yield.

Excavation to 20 ft (= 6 m) shows roots of prairie plants (fig.); with an earthworm population of say 500 m^{-2}, there would be approximately 20,000 worms in this area.

Although earthworms obtain much of their nutrition via dead root material and root exudates (Lee & Pankhurst, 1992), rhizophagy is uncommon (Lavelle, 1983, 1988) but is reported for some species (Baylis *et al.*, 1986; Cortez & Bouché, 1992).

Root mats and organic matter. Through feeding, mixing and stimulation of microflora,

earthworms regulate the rates of mineralisation and immobilisation of soil organic matter (**SOM**). This aptitude varies according to climatic conditions and the precise nature of the organic reserves (Martin *et al.* 1992). In temperate regions, absence of an earthworm fauna is often accompanied by undesirable accumulation of surface litter and root mats. Barley & Kleinig (1964) and later Noble *et al.* (1970) reported that the successful introduction of lumbricids to pasture soil in NSW greatly reduced root mats and stimulated cycling of N locked in this organic layer. From the opposite position, Parmelee *et al.* (1990) and Clements *et al*. (1991) showed that when earthworms were excluded, an obvious build-up of the organic matter occurred in the litter layer. Conversely, earthworms in the humid tropics were found to have contrasting effects on SOM dynamics: accelerating mineralisation (of labile SOM) in the short-term due to digestion, but arresting the decomposition (of recalcitrant SOM) in the long-term by protecting nutrients within water-stable casts (Lavelle *et al.*, 1989; Martin, 1991; Martin *et al*., 1992; Lavelle & Martin, 1992). Thus earthworms activities, although varying with species and region, regulate the rate of mineralization of nutrients from SOM reserves in different but balanced ways in both temperate and tropical environments.

Enzymes. Laverack (1963: 23) reports gut enzymes as including lichenase, protease, cellulase, chitinase, amylase and lipase. The occurrence of cellulase, apparently produced by the intestinal wall in some species, is of particular interest as many plant feeding animals depend upon intestinal flora and fauna to dydrolyse cellulose. An inverase enzyme has also been reported from worm casts. Gut pH varies within 6.3-7.3.

Mesofauna and microorganisms. The trophic, symbiotic, competitive, and synergistic relationships with beneficial or pathogenic nematodes, microarthropods, microorganisms and fungi are complex (Lee & Ladd, 1984; Lee & Pankhurst, 1992). Both external and internal relationships exist. Experimental evidence shows that certain organisms, particularly microflora, are killed during gut transit, whereas others proliferate (Vega & Victoria, 2009). Microfauna populations are also affected, for example, Yeates (1981, quoted in Lee, 1985) reported nematode populations reduced by 37-66% when earthworms were introduced to soils. Senapati (1992) found that mainly plant parasitic nematodes were reduced whereas microbivore nematodes increased. As for Collembola, Marinissen & Bok (1988) ascertained that presence of earthworms favoured survival of both larger species and of more individuals.

Possibly the greatest influences are on protists, other microorganisms and actinomycetes, some of which increase logarithmically after passing through an earthworm's gut (Lee & Ladd, 1984; Edwards & Fletcher, 1988). Some microorganisms are reduced, suggesting they are a major part of the earthworm diet, especially (bacterivorous) protozoa and fungi, algae less so, with bacteria the least important (Lee & Ladd, 1985; Edwards & Fletcher, 1988).

Miles (1963) found that *Eisenia fetida* cultured in sterile soil to which soil fungi and bacteria were added, failed to grow, but when soil protozoa were added, the worms grew to maturity, suggesting that at least in this species protozoa are an important part of the diet.

Mechanisms of mutualistic digestion in earthworms, involving gut symbioses, have been proposed for several members of tropical and temperate species (e.g. Barois & Lavelle, 1986; Martin et al., 1987; Martin, 1988; Lavelle, 1988; Barois *et al.*, 1987; Barois, 1992; Trigo & Lavelle, 1993; Mendez *et al.*, 2004). Moreover, the potential for free N-fixing in the gut has been demonstrated in some earthworms (Barois *et al.*, 1987, reported in Lavelle *et al.*, 1987). Barois (1992) discusses the mutualistic microbiology of *Amynthas corticis* and *A. gracilis*. The intestinal caeca of such pheretimoid species probably serve to culture symbiotic gut flora and microbes (perhaps analogous to complex typhlosoles in other groups), and although I can find few references to the specific microbes involved, there are papers of culturing diazotrophic bacteria from the intestines of pheretimoids (e.g. Risal & Ozawa, 2002; Ozawa & Risal, 2003). Recently Hyun-Jung Kim *et al.* (2004) and Kwang-Hee Shin *et al.* (2004) isolated nearly 200 colonies of aerobic and anaerobic bacteria from the gut of *E. fetida* (*Agric. Chem. Biotechnol.* 47: 137-142; 147-152 http://env1.gist.ac.kr/~aeml/research_3_2004.htm); and Horn *et al.* (2005) described new N_2O-producing bacteria from *A. caliginosa* gut.

Enhanced dispersal and viability of spores and propagules of fungi and microorganisms in the presence of earthworms have been reported for both pathogenic (Edwards & Fletcher, 1988) and beneficial organisms (Buckalew *et al.*, 1982). Beneficial, vesicular-arbuscular mycorrhizas (VAM) were transmitted in casts of 13 species of earthworms, as was *Frankia* (a nodulating, symbiotic N-fixing actinomycete) in one species (Reddell & Spain, 1991a, 1991b). Kale *et al.* (1992) reported increased colonization of plants by mycorrhizae, and higher soil counts of total microbes, especially N-fixers and spore formers, following application of

vermicompost. Recently, the potential dual benefit of reduced severity of *Rhizoctonia* and "take-all" pathology in wheat combined with increased root colonization with symbiotic *Rhizobium* and *Pseudomonas* through earthworm activities were found (Dr P.M Stephens pers. comm.). Experimental effects of vermicompost on some plant pathogens by Szczech *et al*. (1993) found that *Phytophthora* and *Fusarium* fungi were suppressed by vermicompost, but that parasitic nematodes were not affected. Inoculation of sorghum seeds with *Azospirillum brasiliense* and earthworm casts increased growth of sorghum (Savalgi & Savalgi, 1991). Fungal pathogens *Rosellinia necatrix*, white root rot of apples, and *Plasmodiophora brassicae*, clubroot of brassicas, have both been reduced by vermicompost (Stephens *et al.*, 1999). It is further reported that soil borne diseases are less prevalent on organic farms that rely on the kinds of natural microbial activities invoked above (Workneh *et al*., 1993 referred to in Hoitink & Grebus, 1994). A two-year project in Florida has further found that vermicomposting using earthworms to process sewage sludge (biosolids) was effective in reducing pathogen levels (viz. fecal coliform, *Salmonella* sp., enteric virus, and helminth ova) to meet EPA Class A requirements (Eastman, 1999).

Using information mostly from Tanada & Keya (1993: *Insect pathology* Academic Press: 1-666), because so little is known about pathogenicity of microbes to earthworms, a Danish website [Ref, Nov. 2011] produced the following summary table (their Table 2.2) of disease microbes and their effects and/or resistance, with references:

Table of Microorganisms with pathogenic properties interacting with earthworms

Microorganism	**Worm sp.**	**Reference**
Corynebacterium diphteriae	*L. terrestris*	Cameron, 1932
Brevibacterium sp.	*E. fetida*	Roch, 1980
Serratia marcescens	*E. fetida*	Çotyk & Dales, 1984
Bacillus megaterium	*E. fetida*	Valembois et al., 1986
Arthrobacter sp.	*E. fetida*	Valembois et al., 1986
Serratia sp.	*E. fetida*	Valembois et al., 1986

Aeromonas sp.	*E. fetida*	Valembois et al., 1986
Aeromonas hydrophilia	*E. fetida*	Valembois et al., 1986
Yersenia ruckeri	*D. veneta*	Çotyk & Kalaç , 1990
Yersenia ruckeri	*E. fetida*	Dales & Kalaç , 1992
Bacillus thuringiensis	*L. terrestris*	Smirnoff & Heimpel, 1963
Enterobacter aerogenes	*H. suctoria*	Rao et al. , 1983

Their References:

Cameron, G.R. (1932): *Inflammation in earthworms.* J. Patho. Bacteria *35: 933-972.*

Çotyk A. og Dales, R.P. (1984): *The effect of the coelomic fluid of the earthworm* Eisenia foetida *Sav. on certain bacteria and the role of the coelomocytes in internal defence. Comparative Biochemistry and Physiology 78A: 271-275.*

Çotyk, A. & Kalaç, Y. (1990): *Response of the earthworm* Dendrobaena venata *to bacterial infection. I Lésel, R. (ed.): Microbiology in poecilotherms, Elsevier Science Publishers: 245-248.*

Dales, R.P. & Kalaç, Y. (1992): *Phagocytic defence by the earthworm* Eisenia foetida *against certain pathogenic bacteria. Comparative Biochemistry and Physiology 101A: 487-490.*

Smirnoff, W.A. & Heimpel, A.M. (1961): *Notes on the pathogenicity of* Bacillus thuringiensis *Berliner for the earthworm* Lumbricus terrestris *Linnaeus: Journal of Insect Pathology 3: 403-408.*

Valembois, P., Roch, P. & Lassègues, M. (1986): *Antibacterial Molecules in Annelids: I Brehélin, M.: Immunity in invertebrates, SpringerVerlag: 74-93.*

Plant growth factors.

Release of metabolites that stimulate plant growth has been proposed by several authors to explain some of the effects of earthworms on plant growth. Plant growth promoting substances (*e.g.* vitamins, plant hormones, enzymes and amino acids) have been detected in earthworm extracts (*e.g.* Gavrilov, 1962; Nielson, 1965; Graff & Makeschin, 1980; Dell'Agnola & Nardi, 1987). A report of an Indian study in Ishmail (1995) was of plant hormone-like compounds (Cytokinins were benzyladenine equivalents; Auxins were indole acedic acid – IAA – equivalents) in casts of *L. maruitii* and *P. excavatus* that diminished in concentration as casts aged over 10 weeks.

Earthworms have been found to stimulate soil enzymes, such as glucosidase and phosphatase (possibly of microbial origin) which influence availability of plant nutrients (*e.g.* Ross & Cairns, 1982; Tiwari *et al.*, 1989). Nielson (1965) first identified indole compounds in extracts of several lumbricids, while Springett & Syers (1979) suggested that auxin-like substances are present in casts. Microbially derived plant hormones (cytokinins and auxins) have also been isolated from earthworm casts and vermicomposts (Tomati *et al.*, 1983, 1988, 1990 and Tomati & Galli, 1995) and Canellas *et al.* (2000) also identified exchangeable auxins attached to humic acid extracted from cattle manure vermicomposts. Edwards & Arancon (2005) provide futher information on plant gowth hormones vound in vermicomposts and associated with humic acids and increased microbial activity. These studies provide evidence that a key mechanism whereby vermicomposts and earthworm casts enhance plant growth is via these plant hormones.

Production of specific plant hormones by earthworm activities gives credance to arguments for plant/worm co-evolution.

3. AGRONOMIC POTENTIAL OF EARTHWORMS

"*It is a known fact that the nomad tribes on Central Africa always pitched their camp on ground covered with worm casts as they found that this was the best grazing.* " Sir Bernard Greenwell (1937 quoted by Lady Eve Balfour, 1943: 100).

"*Even without appreciating or knowing much about the soil life he cannot see, the farmer will know that his soil is as it should be when he can see that it contains a large and vigorous population of earthworms*". P.A. Yeomans (1958).

General constraints on plant growth are: water, nutrients, predation (including disease) – all of which can be influenced by earthworm activity – plus sunlight/shade. Plant productivity is determined by whichever factor is most limiting. Interactions with soil physico-chemical and biotic factors, i.e., the mechanisms by which earthworms modify their environment, will be considered in a later section. Here, the concern is the direct effects of earthworms on soil fertility as is measured most effectively:- by plant growth.

Effects on plant production. Plant productivity studies have generally taken one of two forms: that of glasshouse, core or pot experiments, and that of earthworm modifications in field trials. Reviews can be found in Edwards & Lofty (1977); Lee (1985); Blakemore (1994) and Edwards & Bohlen (1996). Consolidated summaries, including more recent reports, are presented in Table 2, for pot experiments, and Table 3, for field trials. (Note: ony those few references from these tables not cited in the above reviews will be given in the bibliography herein).

A few reported glasshouse studies have assumed negative effects, whereas some other results are overstated. Between these extremes are many variable results which probably relate to species and soil differences and to different methods of study, analysis and interpretation (Table 2). Although permitting better control of the variables, pot trials are often run for relatively short periods of time and several general criticisms have been made (e.g. by Hopp & Slater, 1949; Edwards and Lofty, 1977; Logsdon & Linden, 1992) especially for:

- using unrealistically high populations so that earthworm mortality provides nutrients
- using casts or compost (i.e., earthworm products) rather that the direct effects of live earthworm activity
- failing to differentiate between earthworms increasing soil fertility and earthworms thriving in fertile soils

- failing to report negative results
- inadequate description of species and soils
- insufficient replication leading to poor statistical validity.

Glasshouse experiments are frequently used to investigate potential and mechanisms, but findings do not necessarily translate directly to the more complex field situation (as discussed by Mackay *et al.*, 1982; Wright & Coleman, 1988; Teuben & Verhoef, 1992; Blakemore, 1994). On the other hand, field experiments have typically involved inoculation of field sites where the natural populations are sparse (Table 3), or by comparison with sites where the natural populations have been removed or reduced (e.g. Parmelee *et al.*, 1990; Clements, 1982; Clements *et al.*, 1991; Edwards & Lofty, 1982) or removal then re-introduction of various components (eg. Edwards & Lofty, 1980). A problem with field experiments is finding sites which are completely worm-free, consequently perhaps the most definitive results have come from areas such as previously glaciated Canada or parts of New Zealand and Australia where the native fauna declined following tree-clearing for pastoralism and exotic species had yet to colonise (*e.g.* Waters 1951, 1955; Langmaid, 1964; Springett, 1985; Blakemore, 1994, 1997), or in land reclaimed from water (*e.g.* vanRhee, 1969; Hoogerkamp *et al.* 1983, Curry & Boyle, 1987) or from deserts (*e.g.* Temirov & Valiakhemedov, 1988). Quantification of responses solely attributable to earthworms is difficult to obtain in the field in the short-term due to the myriad of variables. Perhaps earthworm survival is a better measure or, in case of land rehabilitation, the improvement of soil, rather than plant production *per se*. The time period for results to stabilise is also a consideration. Negligible or deleterious effects on crops are sometimes reported (*e.g.* Puttarudiah & Sastry 1961; Rose & Wood, 1980), but positive effects are more commonly reported in publications (Table 3).

Another means of comparison is correlation of earthworms with plant yields in adjacent or similar soils/climates, e.g. the Haughley earthworm study (Blakemore, 2000). Waters (1955, as sumarized in his figure here) found high correlation of 0.87 between earthworm weight and NZ pasture yields. Recently a correlation between earthworm abundance and crops in a meta-analysis by vanGroeningen *et al.* (2014) of 58 studies, including one by myself (ref.), found an average extra 25% yield.

Table 2. Summary of pot or 'mesocosm' experiments of earthworm effects on plant yields (treatment effects are the difference in responses of treatments compared to controls expressed as a percentage of the control values) plus observations.

Workers	Dates	Countries	Spp.	Plants	Treatment effects relative to controls (%)
Wollny	1890	Germany	lumbricids	crops	"useful effects"
Russel	1910	U.K.	lumbricids	?	25%
Hopp & Slater	1948	U.S.A.	mixed lumbricids	hay/clover	-48% — 495% (mean 150%)
Hopp & Slater	1949	U.S.A.	*Aporrectodea caliginosa/ Diplocardia sp.*	millet	11% (difference not significant)
				lima beans	8% (difference not significant)
				soybean tops	248%
				wheat grains	20%
Nielson	1951/3	N.Z.	mainly lumbricids	turves & grass	58% — 98% & 31% — 110%
Waters	1951	N.Z.	*A. caliginosa*	rye grass	<190%? (worms removed)
				clover & grass	-3% — 117%
Ponomareva	1952	U.S.S.R.	?	crops	400%?
Zrazhevskii	1958	U.S.S.R.	*A. caliginosa*	oak & ash saplings	26% & 37%
Atlavinyte *et al.*	1968	U.S.S.R.	lumbricids	barley	92% — 201%
vanRhee	1965	Holland	*A.longa/L. terrestris*	grass,wheat,clover	287%, 111%, 877%
Marshall	1971	U.S.A.?	*A. caliginosa/L.terrestris*	black spruce	significant increase >1 yr.
Atlavynte & Pocine	1973	U.S.S.R.?	*A. caliginosa*	oats	20% — 50%
Aldag & Graff	1975	Germany?	*Eisenia fetida*	oat seedlings	8.7% (21% protein)
Edwards & Lofty	1978/80	U.K.	4 lumbricid spp.	barley	some plant increases
Graff & Makeshin	1980	Germany	lumbricids	ryegrass	10% (using exudates)
Abbott & Parker	1981	Australia	*A. trapezoides*	ryegrass	-23%
Atlavinyte & Vanagas	1982	Lithuania	*A. caliginosa/L. terrestris*	barley grain	4% — 220%
Mackay *et al*.	1982	N.Z.	*A. caliginosa/L. rubellus*	ryegrass	2% — 40%
McColl *et al*.	1982	N.Z.	*A. caliginosa*	ryegrass	5% — 50%

Atlavinyte & Zimkuviene	1985	Lithuania	*A. caliginosa*	barley	56 — 96% germination x 20
James & Seastedt	1986	U.S.A.	*A.caliginosa/Diplocardia sp*	bluestem shoot	-7% — 18%
Kladivko *et al*.	1986	U.S.A.	*Lumbricus rubellus*	corn seedlings	greater emergence
Sharma & Madan	1988	India	earthworms & dung	wheat & maize	slight differences
Temirov & Valiakhmedov	1988	Tajikistan	"*Allolobophora parva*"	barley	up to 514% yield
Haimi & Einbork	1992	Finland	*A. caliginosa*	birch seedlings	200% in 119 days
Haimi *et al.*	1992	Finland	*L. rubellus*	birch seedlings	28.5% in 1 yr
Spain *et al.*	1992	Africa	5 tropical spp	maize	-12% — 154% in 84 days
			3 tropical spp	green panic grass	-10%—214% in 70 days
Pashanasi *et al.*	1992	Peru	*Pontoscolex corethrurus*	tree seedlings	-80% — 2,300% *
Blakemore	1994/97	Qld	25 spp. native/exotic	grass, oats, sorghum	+80 — 100%**

*Herbivory of control compromised results of Pashanasi *et al.*(1992). **Combinations of 3 different soils were used from clay to sandy soil.

Table 3. Summary of field experiment results of earthworm effects on plant yields (treatment responses expressed as % of the control yields or as observations)

Workers	Date	Countries	Spp.	Plants	Response (re ctrls)
Wollny	1890	Germany	Lumbricids	crops	"useful effects"
Ribaudcourt & Combault	1907	Belgium	Lumbricids	crop?	increased yields
Kahsnitz	1922	U.S.S.R	Lumbricids	peas/oats	70%
Dreidax	1931	Europe?	Lumbricids	winter wheat	increase
Waters	1951	N.Z.	Lumbricids	pasture	correlation
Uhlen	1953	Sweden	*L. rubellus/L. terrestris*	barley garden	increase
Duff	1958	N.Z.	*A. caliginosa*	natural grassland	70% in 5 years
Stockdill	1959	N.Z.	*A. caliginosa*	10 yr old pasture	72%
Stockdill/Cossens	1969	N.Z.	Lumbricids	17 yr old pasture	19%- 45%
VanRhee	1977	Holland	*A. caliginosa/L. rubellus*	orchards	2.5%(tops) - 140% (roots)
Noble *et al*	1970	NSW.	*A. caliginosa*	pasture	10% (not sig.)
Atlavinyte	1974	USSR	*A. caliginosa*	barley	78%-96%
Edwards/Lofty	1980	U.K.	4 lumbricids	barley	57%
				roots	181%
				grain	24% (not sig.)
Atlavinyte & Vanagas	1982	Lithuania	*A. caliginosa / L.terrestris*	barley grain	200% + quality
				rye grain	lower + quality
Hoogerkamp *et al.*	1983	Holland	Lumbricids	Polder pastures	10% in 10 yrs
Springett	1985	N.Z.	*A. longa*	pastures	27% in 1½ yrs
Temirov & Valiakhemedov	1988	Tajikistan	"A. parva"	barley in desert	more growth
Curry & Boyle	1987	Ireland	Lumbricids	reclaimed bog	25%-49%
McCreadie & Parker	1991	WA	*A. trapezoides/M. dubius*	wheat	62%
Temple- Smith	1991	Tas.	*A. cal./A. longa*	pasture	60-75% in 2 yrs
Blakemore	1994/ 1997	Qld.	12 species, some natives	pastures a & b	27-65% in 1 yr

Whether in pots or in the field, most experiments have used lumbricids, that is members of the family Lumbricidae e.g., *Aporrectodea*, *Eisenia*, *Allolobophora* and *Lumbricus*. However, several earlier reports fail to adequately differentiate between species and especially *Aporrectodea caliginosa* and *A. trapezoides* are often confused. Prior to the studies by the author (Blakemore, 1994; 1997) only about six lumbricids and about the same number of tropical species had been studied in any detail with regards their effects on plant growth (Lee, 1992). Considering that there are about 6,000 named earthworm species (approximately 650 Australian & Tasmanian natives), and that possibly many more remain undescribed, then the range of endemic and exotic spp available for study is enormous. Many earlier (and current!) studies also fail to sample the soils before and after the experiments to determine resident earthworm and survival effects. Thus much work is still required to better understand the effective combinations of species under particular edaphic conditions necessary for enhanced plant production.

Programs to introduce earthworms. Earthworms occur naturally in all soils except where recent vulcanism, glaciation, innundation or dessertification precludes them. Agricultural management practices that remove native vegetation with cultivation and the introduction of exotic crops or pastures, or use of toxic biocides can also deplete indigenous faunas. Thus it is only in virgin soils (e.g. post-glaciation), land reclaimed from oceans such as the Dutch polders, recently cleared lands (e.g. Brigalow in Qld or pastures in New Zealand – however in both these cases natives may be overlooked), or those subjected to intensive agriculture that have depauperate earthworm populations. There are many reports, from around the World, of earthworm (re-)introductions into these kinds of soils to stimulate productivity or to rehabilitate degraded soils.

Ghilarov & Perel (1984) discussed soil amelioration programs in the then Soviet Union. They deemed transportation of earthworms into new areas a significant factor of soil fertility improvement. Such transfers were successful variously:

- in artesian irrigated new oases in Kyzyl-Kum desert
- in new territories irrigated by canal in Turkmenia
- in orchards of Trans-Ili Alatau
- in forest plantations of Trans-Volga semi-desert.

Subsequent studies were conducted by Temirov & Valiakhemedov (1988) in irrigated high-altitude desert soils in Tajikistan; and Vsevolodova-Perel' & Sizemskaya (1990)

who have introduced earthworms under forest plantations in the Caspian Sea region.

For the western regions, Brun *et al.* (1987) discussed prospects and limitations of the biological improvement of soils by stimulation or introduction of earthworms. They concluded that the large scale use of earthworms for soil improvement was feasible. There have been several introduction projects. For example Huhta (1979) introduced *Aporrectodea caliginosa* into coniferous forests in Finland with encouraging results. Knight (1989) summarised earthworm research around the world and reported on a farmer in Scotland who improved pasture by a combination of inoculating his land with earthworms, adding lime and reseeding with clover allowing a 50% increase in stocking rates. In Dutch polders (land reclaimed from water), there have been several well reported introductions (e.g. van Rhee, 1969; Hoogerkamp *et al.*, 1983; Hoogerkamp, 1984), while cleared peat areas in Ireland have also benefited from earthworm introductions (Curry & Bolger, 1984; Curry & Boyle, 1987). In America, worms have been introduced in order to reclaim mine spoil sites (Dunger, 1969; Vimmerstedt & Finney, 1973; Hamilton & Vimmerstedt 1980).

Stockdill (1982) and Springett *et al.* (1998) reported on pioneering work done in New Zealand on the effects of introduced earthworms on the productivity of pastures. The introduction of earthworms to one site resulted in a 70% increase in spring pasture production after four years, which later levelled off to about 30% higher than uninoculated fields (as noted above, infiltration rates were doubled and soil moisture increased by 17%). Cost benefit studies indicated that earthworm introduction presented a highly profitable development opportunity for New Zealand farmers with unpopulated pastures.

From Australia there are only a few published studies: Barley & Kleinig (1964) and Noble *et al.* (1970) which both report on the introduction of *A. caliginosa* into irrigated pastures in NSW. There was a resultant reduction in root mat thickness, C:N ratio and bulk density of the soil. Blackwell & Blackwell (1989) introduced lumbricids and *Eukerria saltensis* in a red-brown earth in NSW and reported increased air permeability. Studies by Abbott & Parker (1981) and McCredie & Parker (1992) in WA culminated in 62% increase in wheat yield (and greatly improved soil structure) three years after introduction of *Aporrectodea trapezoides* and *Microscolex dubius*. A redistribution program in Tasmania using *A. caliginosa* and *A. longa* demonstrated increases in productivity of pasture by up to 70% (Temple-Smith, 1991). Blakemore (1994; 1997) reported on the introduction at two south-east Queensland sites that had

been depleted by previous land-clearing and cultivation, of 12 species of native or exotic earthworms that after one year resulted in pasture increases of 26% and 64% compared to control plots. These latter experiments were have used the most combinations of earthworm species attempted anywhere in the world and the results, despite a persistent drought, were positive and encouraging.

Reports from most other regions of the world are scarce except for a few studies from India and Africa (Ljungström, 1972; Smetacek, 1991; Save & Sanghave, 1992; Lavelle *et al.*, 1992). Senapati *et al.* (2001) have described restoring soil fertility and changing productivity in Indian tea plantations with earthworms (*Pontoscolex corethrurus, Megascolex konkanensis*, *Amynthas corticis* and *Metaphire houlleti*) and organic fertilisers: harvests at some of the plantations in Sambalpur in India are up as much as 282 per cent, and profits up by as much as $5,500 per hectare per year [http://www.fao.org/ag/agl/agll/soilbiod/default.stm].

A particularly un-Down-to-Earth project has been to introduce earthworms (*Eisenia sp.*) to Pico de Orizaba, Mexico as a prelude to its 'terraforming' the planet Mars (Neri-Galeno & Cruz-Kuri, 2005). Furethermore, adding these composting worms from commercial suppliers that are unlikely to survive would hardly benefit desert soil.

Management to Encourage Natural Recolonization and Repopulation. Inoculation of inappropriate species that will not survive in particular habitats is as futile an exercise as is the subsequent return to deleterious management practices that will disfavour their continued survival. Moreover, deliberate introduction will only fast-track recolonization by natural processes into soils where conditions suitable for earthworm habitation are maintained using beneficial practices such as mulching, covercrops, swails, stubble retention/reduced tillage, companion planting, and ley rotations. From the research and literature (e.g. Howard, 1945; Yeomans, 1954, 1958; Lee, 1985; Mollison, 1988; Haines & Uren, 1990; Buckerfield, 1992, 1993; Blakemore, 1994, 2000, 2018; Lee, 1995: 229; Buckerfield & Webster, 1996, 1998; Kladiviko, 1997, Chan, 2001), beneficial management practices aiming to reduce severe fluctuations in physical, chemical and biotic conditions, can be used in combination and might include measures to:

- maintain high humus levels by returning organic matter to soils; ley rotations
- build swales or divert channels to conserve water and/or irrigate (Keyline)
- raise pH by applying lime and avoiding chemical fertilizers

- reduce erosion (e.g. contour ploughing, Yeomans' Keyline design, block rills)
- use cover crops, stubble retention, and surface mulching
- reduce compaction from trampling and traffic (e.g. cell grazing, wide tyres, avoiding land when waterlogged, deep-ripping)
- provide shade, hedgerows, "silvopature" and other 'nature' corridors
- reduce or eliminate tillage (but beware of deleterious replacement herbicides!)
- reduce or eliminate biocides (fungicides, herbicides, pesticides and drenches)
- add gypsum to sodic soils or some charcoal (not biochar) where Carbon is low
- maximize edge-effects by increasing boundaries (see Mollison, 1988)
- perform cost/benefit analyses factoring in biodiversity, soil structure and water conservation assessments

Australian compost trials by Buckerfield & Webster (1996) demonstrated that Barossa Valley vineyards benefited from the applications of organic mulches under-vine rather than 'normal practices' of keeping the soil bare. Higher soil moisture (34%), significant grape yield increases (46%) and increased earthworm density (155%) were all recorded. Effects of adding vermicomposts plus other soil conditioners such as the tofu by-product "*okara*" may be complemented by using the Japanese "*EM Bokashi*" standing for "*Effective Microorganisms*" – a kind of anaerobic silage product high in sugars that is applied to fields dried, to avoid blooms of pathogenic microbes, and often it is mixed with other organics like rice husks. Some advocates (biochalatans?) convert rice husks, cotton boll shells or other resilient wastes in to charcoal rather than compost as in "*Terra preta*" schemes – the intentional addition of charcoal (marketed as "AGRICHAR", "biochar" or somesuch) to soil with claimed additional benefits of locking-up of organic Carbon. Links for further information about these highly restricted and dubious *Terra preta* type soils are: http://www.agnet.org/library/eb/430/ and here. Charcoal has **no evidence of any benefit over conventional compost** and may have several disbenefits, especially if earthworm or other soil biota are depleted.

Many synthetic agricultural (and horticultural) chemicals can have adverse effects on earthworms to greater or lesser degrees, for examples see the arguments proposed by Rachel Carson in "*Silent Spring*" (1963). Various known pesticides toxicities are listed by Lee (1985) and their effects by Eisler (2000); herbicides such as glyphosate can also affect some species, e.g. Morowatti (2000) found a 50% mortality in the population of earthworms even at recommended field dose. Paraquat

is now banned. In (Orissa) India, chemicals reduced populations to only four common species in rice fields (Sahu &Panda, 2006): *Ocnerodrilus occidentalis*, *Lampito mauritii*, *Glyphidrilus tuberosus* and *Drawida willsi* Michaelsen, 1907 that is often dominant (>80% in numbers and biomass) and was used in ecotoxological studies with biocides.

Little information is available on the potentially damaging effects of introduction and widespread use of GMOs (genetically modified organisms), LMOs (living modified organisms), GE (genetically engineered) or 'transgenic' crops on earthworms but certainly this is a global issue of major concern (Horton, 2000) that will only get more controversial with increased use, as with earlier use of agrichemicals - but with orders of magnitude of increased risk. [See *Seeds of Deception* Jeffrey Smith's website, offering another view to that proposed by some litigious organizations that brought us Agent Orange, Roundup, Aspertame, and now GMO's (wiki)]. Saxena & Stotzky (2001) found that *Bacillus thuringiensis* (Bt) toxin released from root exudates and biomass of Bt corn had no apparent effect on earthworms experimentally, but, as far as I am aware, no feeding choice trials nor long term effects have been studied. Bt was one of the tools in the organic farmers pest control armory, its wider use increased risk of resistance.

Eroded or degraded and impoverished soils are easy to observe and define, however healthy soils are more difficult to discern. Soils are usually considered 'healthy' when they are able to produce crops, store carbon from the atmosphere and regulate water flows. Often such soils will have a healthy community of soil biota too.

Organic or integrated practices seem to establish beneficial soil biota effects, e.g. Blakemore (1981; 1996; 2000, 2018) demonstrated that organic sections had enhanced earthworm abundance, by up to 4 times, and diversity compared to plots subject to conventional agriculture (see also Buckerfield, 1993; Ref., 2006). In later research from N.Z. Reganold *et al.* (1993) reported:

> "*Earthworms were counted on the two market gardens to give another indication of biological activity. From 30 soil cores (15 cm in diameter by 15 cm deep) taken on each paddock, we found the biodynamically farmed soil to average 175 earthworms per square meter compared with 21 earthworms per square meter on the conventionally farmed soil. By mass, the biodynamically farmed soil had 86.3 g of earthworms per square meter, whereas the conventionally farmed soil had 3.4 g of earthworms per square meter. These differences were most likely due to the use of pesticides, shown to reduce earthworm populations (8), on the conventional farm.*"

And biodynamics.org.nz (2004) reports that earthworms were most effective in a comparative trial in Europe:

> "*Other larger soil organisms are also important in releasing nutrients from soil organic matter. In the long-term European DOC trial, biomass and abundance of earthworms were higher by a factor of 1.3 to 3.2 in the organic compared to mineral plots (Maeder et al. 2002). Average activity density of carabids, staphylinids, and spiders, which they consider sensitive indicators of soil fertility, was almost twice as high in the organic compared to mineral plots.*"

Recent studies of comparative farming methods growing tea in Assam, India and coffee in Costa Rica found that organic management favors high earthworm density and biomass and that coffee yields under organic management can equal those of conventional systems (Pareek, 2004; Sanchez de Leon *et al.*, 2006). More importantly, food security in Africa may hinge on organic agriculture found in studies by UNEP (2008) to increase yields by an average of 116% (128% higher for projects in East Africa) whereas introduction of conventional (i.e., non-organic) agriculture to Africa lowered food production per person by 10% when compared to the 1960's.

Several workers have suggested that earthworms may be suitable as bioindicators (e.g. Rovira *et al.*, 1987; Lal & Stewart, 1992; Buckerfield *et al.*, 1997; Fang *et al.*, 1999; Paoletti, 1999; Blakemore, 2000). As already noted, it has been suggested that farmers should aim to increase earthworm populations, rather than just concentrations of plant nutrients in the soil, because if the earthworm community is healthy, then other components of the soil ecosystem will be functioning optimally.

Conclusions. Most terrestrial ecosystems depend upon the 'capital' of soil fertility accrued by the activities of soil fauna over aeons. The beneficial effects of the ubiquitous earthworm have been clearly demonstrated by observation and by scientific experiment. Pot or field experiments have historically used lumbricids, however, several earlier reports fail to adequately differentiate between species, especially within the *Aporrectodea caliginosa* complex. Prior to work reported by Blakemore (1994), only about six lumbricids and about the same number of tropical species had been studied in any detail with regards their effects on plant growth (Lee, 1992). Considering that there are ~6,000 named earthworm species worldwide (e.g. 715 Australian & Tasmanian spp.), and that many more remain undescribed, then the range of material available for study is enormous, and slowly we are assembling needed information.

Earthworm activities influence rates of soil turnover, nutrient mineralization and humification of soil organic matter and, significantly, soil moisture content.

Improvements in consistency of soil texture with concomitant increases in porosity, infiltration and soil-water retention characteristics have also been measured for worm-worked soils. Biocatalytic effects on plant growth are well documented, yet good plant growth is possible without earthworms, at least in the short term. The question whether earthworms improve soil fertility, or just thrive in fertile soils has now been largely resolved in favour of the former option (e.g. Satchell, 1983: xi-xii; Blakemore, 1981, 2000, 2018). Their contributions are masked in well functioning ecosystems, only becoming apparent when these environments are disturbed and the numbers of earthworms are reduced. Management of agro-ecosystems often disrupts natural relationships and may cause severe deterioration of soil fertility in the long term, requiring large energy inputs to artificially maintain or restore production. Soil degradation, especially in the tropics, has been related to reductions in activity and diversity of soil fauna (Lal, 1988). Efforts to restore or complement the earthworm component in temperate soils have often been met with marked success. Yet only a small selection of species are commonly used. There are fewer reports from the tropics where the promise is for a greater diversity of available species. Gaps in our knowledge are of the range and potential of species most suited to survive in managed tropical soils.

Introduction programs imply a reassessment of farming practices to ensure the survival of earthworms, which then act as monitors of sustainability. Inoculation of inappropriate species that will not survive in particular habitats is as futile an exercise as is the subsequent return to deleterious management practices that will disfavour their continued survival. Moreover, deliberate introduction will only fast-track recolonization by natural processes into soils where conditions suitable for earthworm habitation are maintained using beneficial practices such as mulching, covercrops, swails, reduced tillage, companion planting, and ley rotations (e.g. Yeomans, 1954, 1958; Mollison, 1988; Kladivko, 1997, Chan, 2001 – see Table below).

Table of Earthworm populations on silty clay loam near West Lafayette, Indiana.

Crop*	Management*	Earthworms/m^2
Cont. corn	Plow	10
Cont. corn	No-till	20
Cont. soybeans	Plow	60
Cont. soybeans	No-till	140
Bluegrass-Clover	Alleyway	400
Dairy pasture	Manure (lo)	340
Dairy pasture	Manure (hi)	1,300

**Crop and Management systems had been continuous for at least 10 years. Earthworm species not reported (or not available)*. [From Kladivko, E.J. (1997): *Earthworms and Crop*

Management]. Note her comparison of no-till to natural manure applications (albeit on pastures) rather than comparing with cultivation only. Most studies miss this key aspect, failing to consider more natural alternatives in their direct drill/no-till reports and are seriously flawed for this reason! Organic no-till methods provide some benefit but hazards of agrichemical no-till are herbicide polution and use of GMOs (and biased studies!)].

Options for encouraging earthworm survival become more attractive, both economically and environmentally, as our understanding of the beneficial activities of balanced soil communities increases and as the problems of topsoil degradation become more critical. Much work is still required to better understand the most effective combinations of species, especially natives that are adapted to particular edaphic conditions necessary for sustained plant production. Preliminary work by detailed eco-taxonomic survey and production of useful species guides is yet required in order to comprehend and preserve this vital resource and to prove methods for soil restoration, such as in the following example:-

An example of restoration is given by Hill (2003) who quotes Sir C. Stanton Hicks (1955) on Yeomans' Keyline farming result:

"*The bare ridges became covered with lush pasture. Erosion in the valleys ceased. Earthworms, which had never been seen, appeared in their myriads. Soon bare loose red shale became submerged in rich black soil…. In three years he has produced four inches of friable black soil where bare weathered shale or sandstone so recently comprised the barren soil….*"

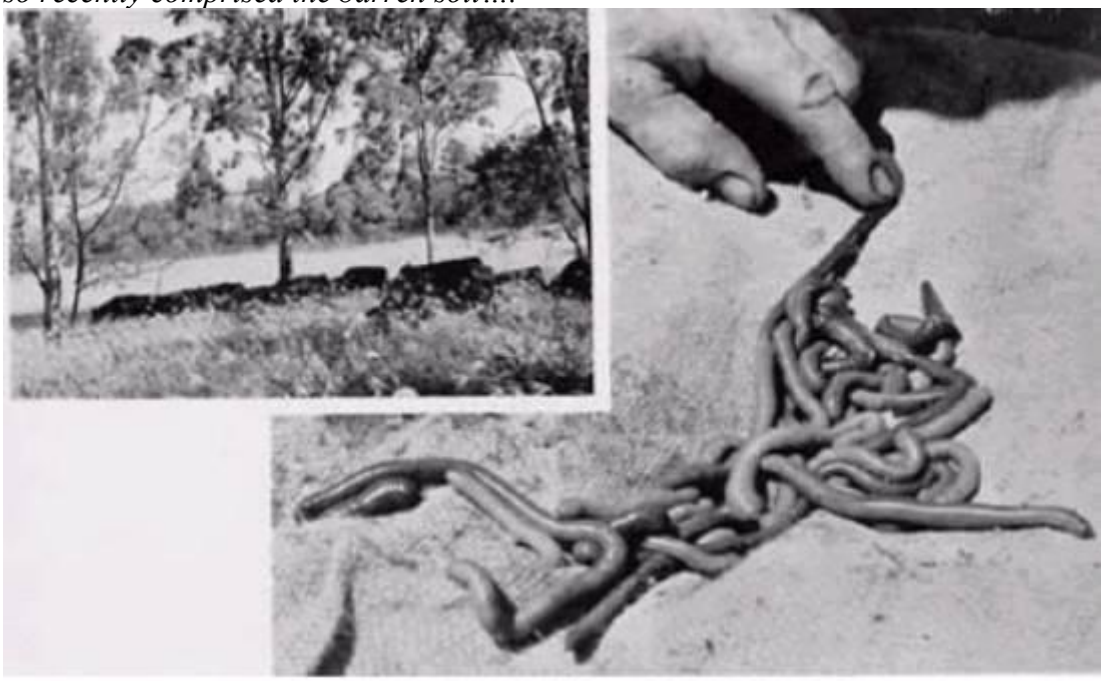


Figure 0.10. Keyline Outcomes: "*Ten centimeters of new topsoil was created in three years – something that was previously thought to take around 800 years! Earthworms emerged in abundance, the size of which (over 60 cm or 24 inches) had never been seen*

before in the [Riverland] Region." from Yeomans (1958). The photo shows lush growth on what had been very low-grade pastures. The other picture shows the worms mentioned previously (after Yeomans 1958: Pl. 30). Quotes and photos courtesy of Laceweb Homepage concerning P.A. Yeomans Keyline system on Nevallan farm, Richmond, NSW: http://www.laceweb.org.au/Chapter%20Three.htm Photo 16; and www.soilandhealth.org/01aglibrary/010126yeomansII/010126toc.html [July, 2005].

4. NUTRITIONAL AND MEDICINAL USES

Nutritional.

Important components of natural soil-food-webs, earthworms are readily collectable and high in moisture and protein (55-80% dry mass, 10-20% wet), with high amino acids and vitamins (eg B12) and low lipids. They are used in aquaculture and as forage foods for domesticated stock such as pigs or fowl. In New Guinea, locals give the vernacular name "*senis gogay*" for particular worms (maybe *P. corethrurus*) that their domesticated pigs thrive on [Rose & Wood (1980); Sillitoe (2003: 88)]. In addition, they have traditionally provided a food resource for New Zealand Maori, Australian aboriginals (Stephenson, 1930), peoples of southern China, Vietnam and Taiwan, for native South Americans (Moreno & Paoletti, 2004), and for soldiers (Wiseman, 1995). "*Earthworm soup*" is a traditional Korean nightcap.

Medicinal.

Their intimate association with soil constantly exposes them to all manner of pathogen and parasite, challenging their immunity and body defences (Ref.). Dorsal lymph glands may also function for biodefence. In China, medicinal use of earthworms (called "*dilong*") has a history of nearly 4,000 years (Zhang *et al*. 1992). Exploiting their natural immunity, earthworm preparations have many uses in traditional and modern Chinese/Viet zootherapy medicines and in the Indian Unani system. Julka (1988: 42) lists some of the treatments and practitioners in India such as for treating pyorrhoea, small pox and for nursing mothers in Burma. He also reports that Cherokees used earthworm poultices to draw out thorns. Earthworm extracts include patented lumbikinase that is thrombolytic and fibrinolytic e.g. Mihara *et al.,* 1992 (claimed from *L. rubellus* but more likely to be *E. fetida*) with potential to alleviate blood clots in stroke patients. Other enzymes are reported to have contraceptive properties as spermicides (Zhang *et al.*, 1992). Earthworm extracts are claimed to provide, cosmetic, pesticide, antibacterial and antibiotic properties (e.g. Sun *et al.*, 2007; Wang *et al.* 2007) and their immunity is a model of competence [Ref.], see too Blakemore (2015).

Earthworms also have enormous 'vermiceutical' and 'bioprospecting' potential (e.g. Titov *et al.*, 2006) since they offer ancient sources for food and medicine and, moreover, their immunity has been found in recent studies to have antibiotic and anti-tumor properties on cancer cells (e.g. Gonzalez, 2004; Cooper *et al.* 2004; Cooper, 2005; Chen *et al.*, 2007). Studies by Dr Ed Cooper at UCLA have shown that their leucocytes and serum kill bacterial and cancer cells *in vitro* (see Engelmann *et al.*, 2003;

2004). Anti-bacterial and antifundal properties of *Eudrilus eugeniae* extract extend to combatting antibiotic resistant strains including Golden Staph (*Stephylococcus aureus*) e.g. Agrawal *et al.* (2014) as summarized by Blakemore (2015). Thus using earthworm extracts and derivatives can extend traditional cures into novel curative applications for modern pharmacological medicine.

5. ECO-TAXONOMY

"*Sine systemate chaos*"
Titlepage to *Das Tierreich*,
Michaelsen (1900).

[The April 2004 issue of *Philosophical Transactions series B (Royal Society)* contained excellent summaries on "**Taxonomy for the twenty-first century**" published online 18 March, 2004 with contributions from Peter Raven, Daniel Janzen, Robert May, Peter Crane and E.O. Wilson, that include arguments in support of strengthening practical taxonomic capacity rather than diversion of funds and resources to generating hypothetical phylogenies].

Introduction

A starting point for any ecological study is inventory and the correct naming and classification of the biotic components with reliable taxonomy and, without this, ecological and environmental studies are irrelevant (Dominguez *et al.*, 2005). The comparative anatomy of phenotypic expression is used by morphological taxonomists (cf. genetic products used by molecular analysts, and behavioural traits used by ethnological ecologists). Some understanding of functional anatomy is required for a better appreciation of variability and comparability, this in turn relates to the evolutionary history and ecology of an organism.

In earthworm systematics, most importance is given to the reproductive organs as these are not only prominent and expensive for the individual to maintain, they are also the most conservative - less affected by environmental influence through time. As Stephenson (1923: 7) said: "*The sexual organs are the most important of all for systematic purposes*". Thus the number and positioning of the testis, the openings of the male pores, the form of the prostates, the ovaries and their means of shedding eggs, and the thickness of the cells forming the clitellum, assume primary importance in earthworm systematics; while the spermathecae that store sperm are also of interest. Sims, (1980, 1982) presented a classification of earthworms incorporating morphology of the ovaries as was initially proposed by Gates (1976).

Digestive and excretive physiologies are important, but are probably more adaptive, influenced by environmental and climatic factors such as pedology and prevalent soil moisture. The "*well known dependence of the conformation of the alimentary tract on food and environment*" (Stephenson, 1930: 720) means that the degree of development of gizzards, calciferous glands, and of the intestine often take secondary rank. Similarly, the nephridia that remove waste products from the coelom and serve for osmo-regulation have traditionally been accorded some systematic

importance, especially the division between **plesiomorphic** (‘**primitive**’) holoic and **apomorphic** (‘**derived**’) meroic nephridial states. [Throughout this text, nephridial terminology follows Gates (1972) who avoided unnecessarily long terms such as:- ‘holonephridial’ and ‘meronephric’ that have the same meaning as holoic and meroic, thus avoiding tautologies such as “*megameronephridial nephridia*” or “*Nephridia: micromeronephridia median to mega-meronephridia*”. These simpler terms are also used in wider invertebrate morphology dictionaries, e.g. http://digitalcommons.unl.edu/onlinedictinvertzoology/2/ Sept. 2005]. Finer distinctions of the nephridial systems have been found to be unreliable and discredited characters for higher classification, or of uncertain systematic significance, and are believed to be ‘adaptive’ (e.g. Easton, 1979: 9, 17-20; Sims, 1980: 105; 1982: 284).

The nervous and vascular systems are sometimes credited with significance at higher than the species level (e.g. by Gates, 1972), while the respiratory system, which in terrestrial species at least is simple gaseous exchange through the epidermis, is not utilized at all.

Those characters that are perhaps most adaptive, or rather those most subject to immediate environmental influence, and therefore of lesser interest are the superficial external features of the worm such as the colouration, and, because worms are soft-bodied, their precise biometry. However, setal arrangements are important, especially the development from primitive/plesiomorphic lumbricine (8 setae per segment) to derived/apomorphic perichaetine (more than 8 setae) states, these being indicative of phylogeny as well as ecological strategy. An intermediate stage, that seems particularly common in Australian species, is the ‘anisochaetine’ state where there are 8 setae in the anterior that increase in number posteriorly, as found in some members of *Anisochaeta*. External genital markings that serve for recognition, attachment, and alignment during mating, although somewhat variable are often highly specific characteristics. Despite the vital importance of characteristic behaviours, these are rarely taken into consideration in systematics, not least because relatively little is known on this subject, especially for cryptofauna such as earthworms that, due to their subterranean, and crepuscular or nocturnal activities, elude ready observation. Changes in behaviour (always?) precede morphological change, they are thus a prerequisite for evolution but, as with cultural developments, they may operate by mechanisms that are not strictly Darwinian in nature.

Collection

Taxonomists, or rather, eco-taxonomists, should ideally be involved in the whole identification process:- from funding and site selection, through ecological sampling and taxonomic identification, to report writing, publication and revision.

Worms are best obtained by digging and hand sorting on a plastic sheet, although various vermifuge solutions or mechanical and electrical methods of collection may be used. Caution is required with hazardous chemicals (e.g. formalin) and electricity, so these are not recommended. Darwin (1881) reported that dilute acetic acid is anathema to worms, but this seems to have been forgotten; iron sulphate can be used (Eisen, 1900: 247) and another effective method is a dilute mustard (e.g. *Brassica* spp) solution irritant to drive them from the soil (Gunn, 1992). In Okinawa, my colleagues and I substituted wasabi (*Wasabia japonica*) powder for mustard but there seemed to be few advantages. Perhaps equally effective, but previously unpublished and presently unquantified, is the anglers' technique of pouring dilute cement (caustic) solution onto the soil surface. Fresh water should be kept on hand to clean the worms of the irritant once collected.

Quantitative results from a site can be obtained by taking 10 or more random samples or from along a transect [note that Swift & Bignell (2001: 9) suggests 8 samples as a target but that five will suffice as a minimum]. Depending on the site variability, usually each of the 10 samples is 0.1 m^2 (e.g. a square quadrat 31.6 cm side) or take 16 of 25 x 25 cm squares (= 1 m^2), progressively sorting through the different layer depths (e.g. 0-5, 5-10, 10-20 cm, etc.) until no more worms are encountered. For cut worms only 'heads' (the anterior portions) are counted, but all parts from the sample should be included for weighing to give biomass estimate. Numbers (abundance) and biomass mean values and standard errors are, by convention, expressed per square metre (m^{-2}) irrespective of the depth of sampling unless stated otherwise. Gates (1972) divided samples into age classes including juveniles and cocoons, and this is recommended, although identification may be tricky.

Qualitative sampling can seek the most abundant locations, e.g. moist soil with lush vegetation; but earthworms may also be obtained at depth from dryer soils, or from under rocks or logs, besides watercourses, in drains, and even from the tree canopy.

Date, location and habitat notes should be taken and any particular behavioural responses recorded. Collection permits are required for survey of National Parks and

State Reserves, some native species are protected by legislation in Australia, and ethical codes of conduct apply to the care and use of animals for scientific purposes.

Representative specimens are washed then placed in a tray or dish of water and, over several minutes, alcohol is added to gradually anaesthetize the worms without causing severe reaction. When a specimen is fully relaxed and no longer responds, it is damped off on tissue to remove any mucus and straightened out for preservation. It can be fixed by immersion overnight in 4% formaldehyde (i.e., a 10% solution of concentrated commercial formalin) - if layed flat in tilted tray or hung by the tail threaded with cotton it will maintain an ideal elongate shape, before transfer to preservative. For molecular analysis, or to avoid the use of toxic formaldehyde, the specimen may be placed directly into alcohol preservative. A most reliable solution is 80% ethanol (EtOH) but methanol may be substituted: any lower concentration will result in the specimen becoming macerated, any higher and it becomes brittle. Alcohols are flammable and carriage by mail or aircraft is regulated. It is important to have a sufficiently large sample jar, with airtight lid, to hold the specimen without dilution (in the order of at least three times ratio of preservative : volume of worms) and to clearly label the sample. The label is written in permanent ink on resilient paper or card that is added to the jar so that it can be read through the glass, or the specimen itself can be tagged. Only marking the lids will invite mistakes later. It is mandatory to deposit taxonomic type material in recognized institutions (ICZN, 1999) and is good practice to also lodge voucher specimens from any agro-ecological study.

Historical collection practices used severe toxic chemicals, even cocaine (Ref.).

Type-locality or type-localites are prescribed by ICZN (1999) which, in Article: 76.1.1. says; "*If capture or collection occurred after transport by artificial means, the type locality is the place from which the name-bearing type, or its wild progenitor, began its unnatural journey*" - which applies to specimens from Botanic Gardens, such as Kew (see Beddard, 1891, 1906; Friend, 1910).

Inspection

Live specimens may be observed in the field and laboratory for their characteristic activities, behavioural responses, and reactions to stimuli. Some species can be immobilized in narrow glass tubes in order to count segments (see Blakemore, 1981), or by compression below base and inverted lid of petri dish to reveal internal anatomy (see Blakemore, 1994). In this way living specimens can be identified before use. After their biometry is taken, specimens are examined externally under a

stereoscopic microscope with an adjustable light source to record the position of setae and external markings and pores. Functional dorsal pores can be determined by applying slight pressure and watching for fluid exuding, and such traction can also reveal the location of other intersegmental pores. For preserved specimens, it is sometimes necessary to remove the cuticle to determine the position of pores. Where the reproductive pores and nephropores are still not visible, they can to be checked with reference the internal position of the organs, although these may enter the body wall at some distance from their exit points. Dissection is by dorsal incision using a scalpel blade from the anterior just below the peristomium and following beside the line of the dorsal pores through the clitellum, sometimes it is easier to cut forwards from the midbody. The specimen is teased open, pinned with fine entomological pins on a tray with black paraffin wax base, and immersed with liquid (water or ethanol) to prevent desiccation. It helps counting if the pins are put through certain segments, such as 5, 10, 15, and 20. Internally the position of the ovaries – almost invariably in segment 13 – serves as a useful reference point to confirm segmentation. A needle and forceps (or fine tweezers) are useful for counting and probing, and sharp-pointed scissors can be used to cut cuticle, muscles, and thick septa. Good visibility is maintained if the dissection is flushed frequently using a syringe. The form, development and position of the internal organs should be noted, each time without preconceptions as to where or how they should occur. Record just what is seen. Spermathecae are often buried under the blood vessels and guts, and need to be teased out, their ampullae may also be checked for nematodes. Prostates can be sectioned to inspect their central lumen and possible side-branches. The intestine should be incised to determine typhlosole development and gut contents.

Desiccated museum specimens may be rehydrated using detergent or warm solution of 0.25-0.5% Tri-sodium Orthophosphate [Van Cleave & Ross (1947) A method for reclaiming dried zoological specimens. *Science* 105(2725): 318], but they may become quite fragile after this and need fixing in a concentration series of EtOH.

It is convenient to use a manilla folder or white card to sketch external appearance and internal organs of the animal on one folio, preferably using a *camera lucida* attachment to the microscope, and to record the corresponding internal organization on the same folio. This image can then be inked on drafting paper or Photoshopped. Morphology can be listed under the headings above, or worked sequentially from segment to segment starting from the anterior to record and sketch

the structures. ***A good policy to have only one jar open on the bench at a time to avoid the confusion of mixed samples and/or labels/lids***.

Anatomical Characters Used in Taxonomy

External Features and Biometry. Body shape, size, pigmentation, number of segments, secondary annulations, and the extent and development of the clitellum in mature specimens are recorded, but these all tend to vary intraspecifically and depending on the methods of preservation, thus are of limited use for identification. Amputees and regenerates are also fairly common and sometimes there is reduction of the first segment (determined by reproductive organs being in other than their normal positions, e.g. ovaries are usually in segement 13 and female pores on segment 14). Presence of a dorsal canal, can be of specific note. An example of variance in colouration and body form of otherwise identical specimens is shown in *Eiseniella tetraedra* from Chichiwan Stream, Wuling Farm, Shei-Pa National Park, Taiwan – the apparent difference between samples is due only to different preservation methods, all specimens are actually the same species (photo here) with another example from BBC online article published 12/09/2008 on effect of worm diet on their colour (here).

Clitellum *(plural, clitella)*. The shape and position of the **clitellum**, the glandular girdle that is sloughed off to form the **cocoon**, is often accorded significance at family, genus or species level, but its exact extent varies according to the reproductive state of the specimen, and it is therefore of questionable systematic use in some cases (although the cocoons themselves may be identified to species). The clitellum can be annular, or saddle-shaped, but sometimes it only appears saddle-shaped due to intrusion or occlusion by ventral genital markings.

Prostomium *(plural, prostomia)*. A prehensile flap over the mouth that is an important organ used to sense the environment and to grip the substrate, its specific characterization is useful. There are four main types, **zygolobous** (rare), **prolobous**, **epilobous**, and **tanylobous**, with intermediate forms between the last three (Fig. 1). In some non-native taxa the worm appears to have swallowed its own head or the prostomium is replaced by a protrusible proboscis (e.g. see *Pontoscolex corethrurus*). The first 'segment' that supports the prostomium and the mouth is called the

peristomium (cf. the last 'segment' that supports the anus and is called the **periproct**, **pygidium** or, more often, the **pygomere**). The peristomium often bears furrows that are extensions from the prostomium and may also have a ventral cleft that probably allows for stretching, however secondary wrinkling, especially in older specimens, can obscure these. Occasionally the pharynx is everted during preservation which can hamper recognition of the prostomium.

Dorsal pores. These allow secretion of coelomic fluid to lubricate and moisten the body surface and to provide protection from predators and parasites. Their level of development and commencement are indicative of whether the species is of aquatic origin (where they are superfluous), or whether the worm needs to generate increased hydrostatic pressure in the anterior for pushing through a compact substrate (where having pores in the anterior would be a disadvantage). Dorsal pores may also be reduced or completely eliminated where exonephric nephridial adaptations, such as bladders or multiple nephropores, replace their function for surface moisture regulation, or where pathogen/parasite entry through dorsal pores (e.g. of nematodes) is problematical. Although the location of the first dorsal pore may be subject to slight individual variation, it often has definite intraspecific limits.

Setae *(singular, seta)*. Small sigmoid bristles, the basic state is **lumbricine**, with 8 setae per segment often in pairs and in longitudinal series in all except for the first and the ultimate 'segments' (the peristomium and the pygomere), that are asetose and support openings of the mouth and anus, respectively. (There are rare exceptions, such as *Amynthas varians* (Chen, 1938: 385) from Hainan, that have setae on the first segment). Occasionally they are reduced or absent from the anterior, and ventral setae are usually deleted from near where the male pores occur on segment 18 or are replaced by penial setae. Any increase in numbers of setae in any part of the body above eight is the **perichaetine** state (Fig. 2). In several perichaetine species there is transition in setal numbers along the body, those that have 8 setae in the anterior increasing in numbers posteriorly are classed as **anisochaetine** (e.g. as found in parts of Australian/NZ *Anisochaeta* and Puerto Rican *Borgesia* James, 1991). Specimens that have lost their tails through autotomy or physical trauma are difficult to identify and, if it is suspected that they are anisochaetine, more material will need to be collected. Setal ratios (for lumbricine worms) are of questionable systematic use as

these vary intraspecifically, depending on the state of the individual or on its method of preservation, and on the technique used to measure and calculate these ratios which differ from one worker to the next; thus separate taxa are often reported with the same setal ratios, and vice versa. However, the setae provide useful reference points for location of external pores and markings.

Setae are often occluded by clitellar tumidity or other genital tumescences, statements such as "*setae absent from clitellum*" are naive, they are present but just not observable.

Penial setae are modified intromittant setae associated with the prostatic pores of some species, often they are enlarged and have hooked, curved, bifid or otherwise ornamented tips. The microscopic sculpturing reported for these are of debatable value as they vary individually, even within a bundle, are damaged or worn by age and use, and may be similar if not the same in several species. Gates (1972: 23) said:

> "*The systematic importance claimed for differences of shape, sculpturing, and ornamentation in those kinds of setae in the classical system, may have been too great. Penial setae may show considerable intraspecific variation or may be similar if not the same in several species*."

Where present, the reliance on penial setal detail for specific characterization requires that these are elucidated for all specimens under consideration (which is not always the case), and is also impracticable for the majority of field workers who lack ready access to high-powered or scanning electrode microscopes (SEM). As to their function it is generally held that they act assist entry of sperm, e.g. Fender & KcKey-Fender (1990: 358) say:

> "*These setae apparently act as an intromittent organ, entering the spermathecal duct and guiding the passage of sperm.*"

However, of particular interest and evident in the presentation of the current author's figures - where a specimen's penial setae and spermathcae are shown *in situ* and to the same scale - is that there is often a corresponding relationship between the length of the penial setae, when present, and the depth of the spermathecal diverticula. This would tend to support the function of the penial setae for scraping out and disrupting any spermatozoa already present in the spermathecae from previous copulation (Visa Nuutinen, pers. comm.). Such action would be of selective advantage to the worm concerned, as it would thus favour its own sperm for fertilization of the partner's eggs. There are exceptions, but it is interesting to note that most of those species described

in Blakemore (2000c) that lack of have reduced penial setae also have duplicated or multiloculate spermathecal diverticula, reinforcing the relationship between penial setae and spermathecae. Penial setae may further assist in alignment and locking of two individuals together, provide stimulation, and act as conduits for the motile sperm to enter the diverticula. **Genital setae**, probably with similar functions, are modified setae not associated with prostatic pores. They are usually enlarged and occur on tumescences, those in the region of the spermathecal pores (e.g. in *Diplotrema*) are called **spermathecal** or **copulatory setae** (these three terms are interchangeable in some accounts).

External pores (Fig. 3). The segmental position and relation to setal lines of the **nephropores** (most obvious in holoic species where they are often intersegmental and visible in lateral series, although they may also alternate with or without regularity), **spermathecal pores** (usually ventro-lateral and intersegmental but highly variable specifically and sometimes even intraspecifically, e.g. in *Metapheretima spieseri* or *M. triciae*), **female pore(s)** (usually on 14) and **male pore(s)** (usually on 15 or 18) are recorded.

Female pores appear single intraclitellarly in some species which may be a slight aberration as they may well be superficially paired when the clitellum is shed. What I don't fully understand is why a female pore should show externally on clitellate specimens if its role is to shed eggs into the clitellum; why then do they appear to open onto the surface? My immediate suggestion is that possibly it simply reletes to the female pore region not secreting the clitellum or to entry of spermatozoa into the cocoon from the spermathecae to fertilize the eggs contained there. It is stilll a mystery to me at present.

The male pores are often superficial on small mounds or papillae called **porophores** (a term more correctly used to describe eversions of copulatory pouches but also applicable to any structure that bears a pore), or they may be inside furrows, copulatory pouches, or in some species they are on penes which may be checked for by suction from a wide-nozzle syringe on fresh specimens. For obvious reasons, in most species the longitudinal position of the male pores usually corresponds to that of the spermathecal pores but the body is flexible and can fold inwards or outwards, and penes provide extension or the body can be bent to access dorsally positioned pores.

Male pore arrangements are called **acanthdrilin(e)** where they are on 18

separate from the pores of two pairs of prostates on 17 and 19 (often co-joined by a **seminal groove**) and this arrangement may be reduced in two ways: **microscolecin(e)** where male and prostatic pores are generally on 17 or **balantin(e)** where male and prostatic pores are generally on 19. The term **megascolecin(e)** describes male and prostatic pores combined on 18. For all of these, homeotic equivalents are possible where anterior segments are reduced or male pores displaced. For all of these, I prefer spelling with the final "e".

***Genital markings*.** Variously arranged external sucker-like discs, pits, grooves, or tumid pads, sometimes associated with internal glands. Those in the anterior, at least in some cases, perhaps represent responses in the individual to attachment by the concopulant, as they frequently correspond, in inverse relation, to the positioning of the 'true' markings found around the male pores. There is often a correlation between the number and position of the spermathecal pores, that require progressive charging with sperm, and of the form and arrangements of genital markings around the male field. Consequently, genital markings, even allowing for interspecific variability, are of great value for identification. In exotic lumbricid species, and some other families, the genital pads are called **tubercula pubertatis** (plural, tuberculae pubertates).

Septa *(singular, septum)*. Internal partitions that separate adjacent segments, these are usually delicate but may be thickened and muscular between anterior segments. Septa are perforated by sphinctered apertures (Bahl, 1919), and are often deflected by larger organs that may also traverse several septa. The degree of development of the septa, and whether they are distended, adpressed, or even deleted in some segments, should be noted. Whilst often displaced slightly in most taxa, in *Drawida* the septa arounf the reproductive organs are so deflected displaced (replaced?) that special care is needed to correctly determine location of organs. As for other groups, perhaps reference to the location of ovaries may be most effective.

Spermathecae (*singular, spermatheca*), (Fig. 4). These are separate from the female pores in most families and usually consist of a large sac, the **ampulla** (plural, ampullae) on a duct that exits at the spermathecal pore and supports a smaller appendage, the **diverticulum** (plural, diverticula) often on a short stalk and with a

dilated terminal bulb. Diverticula are **clavate** ('club-shaped'), **sessile** (without stalk), and/or **multiloculate** (with numerous chambers rather than just a simple bulb). The diverticulum stores spermatozoa arranged in clusters with the tails aligned so that they diffract light and are iridescent. The ampulla is believed to contain nutritive solutions for maintenance and subsequent delivery of the sperm, probably this is received as a product from the prostatic glands of the partner. A question related to this is who 'owns' the spermathecae? Although internal, they open to the exterior and receive and store genetic and other copulatory material from another individual that would presumably be foreign to the body and subject to reaction and rejection. The spermathecae then, can be viewed as invaginations into the body cavity that are essentially external to the body and perhaps actually 'belong' to the other partner(s). The variations in shape and positioning of the spermathecae may be the result of a continual compromise between preserving and enhancing the survival of one's own sperm that is transferred to a mate, and an attempt to disrupt any remnants of a third party's sperm already be stored in the spermathecae, (see also the remarks concerning **penial setae** above). This is expressed as morphological variations, possibly supported by physiological secretions, and, as noted above, often correlated with the degree of development of the penial setae. Other modifications may avoid cross-fertilization or help discourage entry of pathogens or parasites (for example, the nematodes that are sometimes found in the spermathecae). Multiloculate spermathecal diverticula are another manifestation that possibly represent one method of reducing disruption by penial setae, or perhaps more efficient storage of sperm. For these and possibly other reasons, the number, position and shape of the spermathecae although varying slightly within and between specimens are sufficiently constant to be especially useful for identification. In megadriles, the original arrangement is thought to comprise two pairs opening at 7/8 and 8/9, (Gates, 1972) but there may be as many as six or seven pairs, as few as one pair, they may be unpaired, or the spermathecae may be multiple per segment.

Male organs. Testes are small paired organs sometimes enclosed in testis sacs, often surrounded by opaque seminal fluid or mucus, and are detectable mostly by the bright iridescence of their associated sperm funnels. These duct via the **vasa deferentia** (singular, vas deferens) to exit at the male pores (after uniting with the prostatic ducts in megascolecids). In their basic state, they are **holandric**: i.e., paired in segments 10

and 11. Sometimes only a single pair is retained in segment 10 (**proandric**) or in segment 11 (**metandric**). Associated with the testes are **seminal vesicles**, storage sacs where spermatozoa develop, these are usually large paired outgrowths from the septa into the segments adjacent to the testes, often in 9 and 12, but other variations are of specific note. Here is a diagram of lumbricid sperm (red) and egg (green) ducts (Fig.).

Female organs. Ovaries are almost invariably **metagynous**, paired in segment 13 (or its homeotic equivalent in specimens that have deletion or duplication of segments), they appear singly or as sheets of egg strings along with the oviducts that exit at the female pore(s) in segment 14. **Ovisacs** that store ripening eggs, if present, are paired in segment 14 as outgrowths attached to the anterior septum.

Prostates (Fig. 5). These distinct male reproductive organs occur in several families. Consisting of a gland and a duct, the gland is of two main forms: its basic state is **tubular**- elongate with a smooth surface and, when sectioned, with a simple unbranched central canal; non-tubular forms are **tubuloracemose** - where external nodulation and indentations have developed and are connected by small side branches to the central duct internally, the shape of the gland is still elongate but is often flattened, and **racemose** (like a 'bunch of grapes') where the gland is composed of a composite cluster with varying degrees of nodulation and a ramifying canal system, especially obvious where these ductlets branch externally to the glandular parts. The prostate glands provide exudates that help in delivery of sperm to the partner during copulation, and probably charge their ampullae with nutrient solutions, (there appears to be a correlation between the size of the prostates and the combined volume of spermathecal ampullae). In megascolecids, each type of gland connects to the male pores by a muscular **prostatic duct** that receives sperm from the testis via the vasa deferentia that often joins the duct near the junction with the gland, although this is not always obvious. Families are distinguished partly on the degree of prostate development and male pore arrangements; the Ocnerodrilidae, Acanthodrilidae, Octochaetidae and Exxidae variously have either an **acanthodriline**, microscolecine, or balantine arrangement, while the Megascolecidae have a **megascolecine** arrangement. These forms of male pores are shown here. An important distinction for generic (and family) separation is whether the prostates are tubular, or non- tubular.

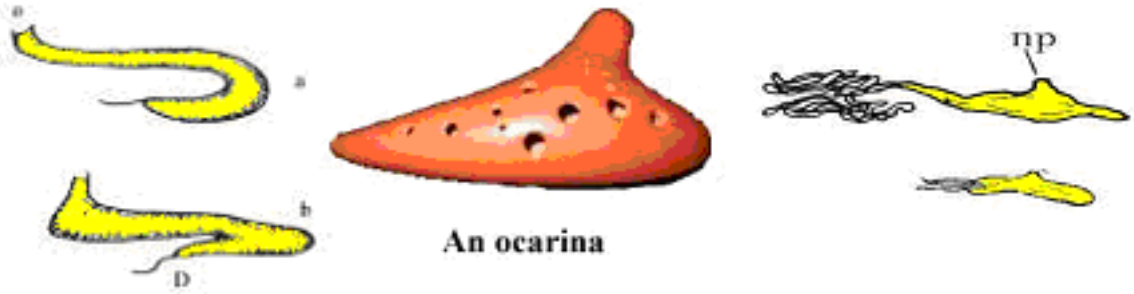
In general, when regarding tubular prostates, the question to ask is if they

resemble the form of those found in the undisputedly more primitive families (e.g. Ocnerodrilidae; Acanthodrilidae), and in the primitive genera of Megascolecidae [e.g. *Pontodrilus*, *Plutellus*, *Sebastianus* (= *Sebbius*)]. Some specimens, particularly those that attain large size by surviving for several seasons, appear to have particularly thick tubular glands as the columnar gland-cells regenerate from the periphery, and these may be easily confused with tubuloracemose prostates (see Blakemore, 2000c: 199). There are also gradations in non-tubular glands, with tubuloracemose glands perhaps becoming more racemose as the specimen ages. It is also possible that the method of preservation or maceration of specimens may distort superficial determination of prostate form.

Nephridial systems (Fig. 6). These exctetory organs have two main states: **holoic** where in each segment there are a single pair of large **holonephridia** ('meganephridia' or 'macroic' in earlier terminology), and non-holic (or **meroic**, literally 'divided') where there is an apomorphic/derived increase in number in any segment, usually in the anterior and often with a reduction in size of these **meronephridia** ('plectonephridia' or 'microic' in some earlier works) that sometimes occur in hundreds in 'forests'. The first few sets of nephridia in both holoic and meroic specimens may be modified as pharyngeal **tufted nephridia** ('peptonephridia' of earlier works) that open into the anterior of the gut and function as 'salivary glands' (see Stephenson Ref). Nephridia may be 'open', where they duct to the exterior (**exonephry**) or to the intestine (**enteronephry**), or 'closed' where they have blind ducts in the coelom. Both holoic and meroic nephridia may attain **vesicles** (bladder-like dilations of the terminal ducts) that aid moisture regulation. Presence or absence of preseptal nephridial funnels (**nephrostomes**) for both holoic and meroic nephridia in caudal segments has been accorded some importance under some taxonomic schemes but detection of these, even where they are present, is often extremely difficult especially where they are micro-meroic, and, when they are absent, the search will be pointless and futile. Meroic species may retain or develop a pair of large (**megameroic**) nephridia in addition to smaller (**micromeroic**) tubules, or their nephridia may be intertwined in the anterior, and they may thus be mistakenly classed as holoic. [Cf. Stephenson (1916: pl.XXXI, fig 9) for a *Lampito dubius* nephridium with multiple funnels, i.e. divided, which he classes as a "meganephridium" (i.e. a megameronephridium) in a meroic species also with micronephridia]. It is important

therefore to accurately determine whether there is just a single pair of holoic nephridia in the anterior segments, or whether additional meroic tubules are present and demonstrable by their separate nephrostomes and/or multiple bladders, in either case ignoring pharyngeal tufts. Bahl (1919; 1945) describes enteronephry in pheretimoids.

When present, bladders may be sausage-shaped, globular (sacciform), ucinate, U-shaped, fish-hook-shaped, zig-zag, or ocarina-shaped, and with or without diverticular apendages (Sims & Gerard, 1999: 10) as in these figures:



[On left-hand side are (a) J-shaped and (b) sigmoid or hook-shaped bladder from Csuzdi & Zicsi (2003: fig. 3.15D - the latter inadvertently labelled "*ocarina-shaped*", possibly after Perels' (1979) mistaken classifications of "*Okarina*", "*Boat-hooked*", "*Fork-like*" and "*Biscuit-shaped*" nephridial bladders – all confused (RJB pers. obs.), as compared to the shape of a real, classical ocarina musical instrument in the middle and, on right-hand side 'ocarina-shaped' nephridial bladders from the current work]. Note: nephridial bladders may vary within a specimen, for example Qiu & Bouche (1998: 21-33, 41-43, 51-53, 82, 99, 158,165, 170, etc.) show variations from ocarina-shaped to hairpin-shaped in many specimens of lumbricid and hormogastrid species.

Anterior digestive system. See Laverack (1963) for physiology of the intestine. The mouth opens immediately to the **pharynx**, the front of which often has an eversible pad, followed after a few segments by the **oesophagus** that usually has a muscular **gizzard** at its anterior end, may be variously modified with calciferous glands during its course, and usually terminates in a pre-intestinal valve. **Calciferous glands** ('chyle-sacs' or the Glands of Morren in earlier literature), is a catch-all term for oesophageal structures that vary from lateral pouches, barely modified with internal lamellae or rugae, to complex extra-mural organs, that serve various functions but, despite the name, do not necessarily contain calcium carbonate. Ocnerodilids

typically have ocnerodriline diverticula rather than strict calciferous glands. In most Indo-Australasian natives the oesophageal gizzard is well developed in or near segment 5. In some taxa there are multiple gizzards, but the gizzard may also be reduced, vestigial, or apparently lacking. Oesophageal (and/or intestinal gizzards where present) may be preceded by a dilated crop, the **proventriculus**.

Vascular system. This is a closed system with a contractile **dorsal vessel** (sometimes doubled) carrying blood to the anterior and connected by lateral trunks to **ventral vessels**. There may be a **supra-oesophageal** vessel on the oesophagus, and, usually in post-oesophageal segments, a **sub-neural** vessel below the ventral nerve cord. Vessels and delicate trunks are sometimes difficult to detect unless they are filled with blood, and are easily damaged or broken during dissection. The extent of the dorsal vessel, and whether it is doubled, is recorded, as are any developments of supra-oesophageal vessel. The number and position of the paired **hearts** are noted, these contractile and valved lateral vessels are usually preceded in the anterior by smaller non-contractile pseudo-hearts called **commissurals**. Last hearts are usually found in segments 12 or 13 (or 9 or 11 in more 'primitive' families). Strictly, the hearts are classed as 'lateral' if they connect dorsal and ventral vessels only, 'oesophageal' if connecting supra-oesphageal and ventral vessels, and 'latero-oesphageal' if they join all three (cf. Buchanan, 1910; Bahl, 1921; Gates, 1972).

Nervous system. The **ventral nerve cord** runs for the length of the body, bifurcating under the pharynx via circum-pharangeal connective trunks that reunite to form the bilobed, anterio-dorsal **cerebral ganglion** in segment 2 or 3. The nervous system is particularly well developed in species such as *Vesiculodrilus apris* Blakemore, 2000 from Tasmania that has a cord 3.5 mm wide in the anterior. Certain species have been accorded possession of cells perceptive of light, taste, smell, touch and possibly sound, at least in *Eudrilus* and *Pontoscolex* (according to Eisen, 1900: 146 who describes the auditory organs as consisting of otosome and/or diaphragm).

Posterior digestive system. The **intestine** is usually thinner walled, less vascularized, and wider than the oesophagus, and may also develop paired lateral or single ventral (or dorsal?) pouches called **caeca** (singular, caecum, see Fig. 7) towards its anterior that probably serve to maintain cultures of gut microflora or symbiotic

protozoa. The internal surface area of the intestine is sometimes increased by dorsal infolding called the **typhlosole** (Fig. 8) that may be simple lamellar (lamelliform), bifid, trifid, T-shaped, V-shaped, or variously convoluted and sometimes it is multiple [I also speculate that the folds of the complex typhlosole found in other species also help maintain cultures of gut symbionts by preventing their being fushed out of the worm host, analogous in function to the caeca]. **Intestinal gizzards** occur in some families, e.g. in Lumbricidae they are single in one or more segments between 17-20; they are found relatively frequently in Tasmanian Megascolecidae taxa - they are single, or multiple and moniliform, e.g. in *Anisogogaster** *quini* Blakemore, 2000 *Gastrodrilus driesseni* Blakemore, 2000, *G. iosem* or *Nexogaster sexies* Blakemore, 1997; they define *Pleionogaster*; and also occur variably in several Eudrilidae from Africa. Gut contents (**ingesta**) give an indication of habitat and ecological strategy, this material is processed as it passes through oesophagus and intestine and is voided as earthworm 'casts' or 'castings'.

Casts themselves may provide some indication of specificity as in certain species they are quite distinct in form, relating to the ingesta and the antomy of the digestive system. For example, *Eudrilus eugeniae* casts are small cylindrical pellets, like chocolate cake-decorations; other species have ribbon-like or globular casts. In the descriptions below I have attempted to indicate types of casts produced. Darwin (1881: 108) says that Perrier had identified species from Nice that were believed implicated in the tower-like casts (Darwin, 1881: fig. 2) found there and the three exotic species were: *Perichaeta affinis* Perrier, 1872 (= *Metaphire posthuma*), *Perichaeta luzonica* Perrier, 1875 – a junior synonym of *Lampito mauritii* (and/or *Polypheretima elongata*?); and *P. houlleti* (= *M. houlleti*).

*[Note: *Anisogaster* Blakemore, 2000 was a homonym of *Anisogaster* Deyrolle 1862 (Coleoptera) and *Anisogaster* Looss, 1901 (Trematoda); moreover Tasmanian *Perionychella variegata* Blakemore, 2000 was a junior homonym of Himalayan *Perionychella variegata* Michaelsen, 1907b: 158 that is now, at least by Stephenson (1923), held as *Perionyx variegatus* (Michaelsen, 1907). Both were given replacement names by Blakemore (2010): as *Anisogogaster* and *Perionychella variegogata*].

Other internal features. The presence of peculiar internal organs should be noted, such as **pseudovesicles** (resembling seminal vesicles but in an unusual

location), copulatory glands associated with genital markings, muscularized tendons, 'lymph glands' on the intestine, or parasitic artefacts that are particularly evident where the worm is infected with Gregarine protozoans, dipteran larva, or nematodes. For accounts of internal parasites see Stephenson, (1930), Gates, (1972), Lee, (1985), Yeates *et al.* (1998).

Identification – Taxonomic classification and nomenclature

Progress in taxonomy is characterized by using latest genomic and computer technology while also laboriously investigating by survey in the field, or trawling of museum collections and delving through the original sources of earliest published records back to Linnaeus (1758), or of seeking representative type material, along with other evidence, in order to answer the simple, basic questions about a species' identity and a regions' biodiversity. In many ways it is similar to detective work combined with auditing along with some forensic science.

Three phenomena seem to characterize modern taxonomy: Firstly that historical, obscure and classical papers are increasingly available online; secondly that molecular/genomic techniques seem to allow greater precision and definition of taxonomic boundaries; and finally that electronic publication allows both rapid compilation and dissemination of taxonomic results, from minor nomenclatural changes to large regional monographs, that may be readily updated (or replaced).

A good overview of Biodiversity Informatics - the application of information technology to the domain of biodiversity - is provided by Stanley Blum at California Academy of Sciences (Oct. 2000), who says:

> "*Taxonomic databases fall into two major categories: nomeclators and checklists. A* ***nomenclator*** *is a compilation of all relevant names, but does not present opinions about which taxa are accepted or valid. A* ***checklist*** *represents determinations about which taxa are accepted or valid, and for each taxon gives its correct name a list of synonyms, and places all taxa in a single coherent classification*"
>
> (www.calacademy.org/research/informatics/sblum/pub/biodiv_informatics.html).

Thus a ***Nomenclator*** is an objective, but static, list that rather pointlessly allows resurrection and perpetuation of synonyms, while a ***Checklist***, although more subjective, is more relevant and useful. A third category of ***Enhanced Checklist***, are like those compiled by Blakemore (2005; 2006/7) listing valid names and synonyms,

as well as any misspellings, *lapsae* or *nomena nudae* so that an online search will stand a better chance of a 'hit'. An ambitious aim for a similar database is by uBio's **NameBank**: a "*biological name server*" focused on storing names and objectively-derived nomenclatural attributes as a repository for all recorded names including scientific names, vernacular (or common names), misspelled names, and ad-hoc nomenclatural labels that may have limited context while serving nomenclatural concepts as XML objects - see http://uio.mbl.edu/nameserver/index.html.

In this age of informatics, it makes sense to have but a single, complete and correct database of names (with their distributions and ecological information) to which new names may be added as soon as they are proposed. Several organizations and individuals, including myself, are independently working on this.

Useful tools are the Biodiversity Heritage library website (www.biodiversitylibrary.org) that will search references online using citations of a species' name, e.g., http://www.biodiversitylibrary.org/name/Drawida%20barwelli; the INTERNET ARCHIVE https://archive.org/ and, to a lesser extent, the ambitious www.bionames.org that also links to original descriptions and molecular phylogenies. Just for New Zealand there is the Canterbury Uni., BUGZ website for online references on earthworms (http://www.bugz.org.nz/WebForms/SearchForm.aspx?useFreeText=False&searchType=0&doSearch=true).

The Zoological Nomenclator of genera names by S. Airey-Neave is online here: http://uio.mbl.edu/NomenclatorZoologicus/ [March, 2006], and species names are listed on Thomson-Reuter's BIOSIS Index to Organism Names (the "ION" nomenclator that is now relaunched on http://www.organismnames.com with the seach facility here), or on the GBIF name search (includes some museum collection databases), or the Global Names Initiative, GNI. The GNI has >18 million taxa (many repeats of synonyms) while the ION database has over 1.4 million animal names, at all taxonomic ranks, reported from the scientific literature since 1978 but the system will not deliver a list of valid organism names (see *Species 2000* for an international project with this intention that provides a partial checklist to some species, see http://spice.sp2000.org/search.php).

Other sites worth watching for development are Zootaxa, Zookeys, Encyclopedia-of-Life, Tree-of-Life, Taxonomicon and Wikispecies.

Under the auspices of ICZN and *Zoological Records* a new resource is

ZooBank – aiming for a universal register of all animal names (see *Nature*, 2005). Other initiatives are TDWG, TaxonX, TaXMLit, DarwinCore etc. (Penev *et al.*, 2008), or BM's fledgling Earthworm Collections database (earthworms.myspecies.info).

Genbank list DNA nucleotide sequences for species without quality control checking for accuracy of the name, thus all results are often highly dubious.

The British BIOME website provides various links to Museum collections and databases worldwide here: http://biome.ac.uk [Feb, 2005 – seem to be gone by 2008].

Dr Csaba Csuzdi's Hungarian database of most earthworm species names is online here and the Nomenclatura Oligochaetologica is here.

A recently commendable effort – PLAZI – links spp names to descriptions, as for BIONAMES.

Identification - Summary of Taxonomic Process

A classification is an information storage and retrieval system that permits you to locate an item with a minimum of effort and loss of time (Mayr, 1998). Biological classification aims to be universal, hierarchical and phylogenetic: Species→Genus→Family in that palaeological order. Ideally it is also a relatively stable system. As species are the essential building blocks of taxonomy, the systematics process is from the 'bottom up', rather than from the 'top down'. The formation of scientific species names by taxonomists is regulated, up to the rank of superfamily level (ICZN, 1999: Art. 27.2), by the rules and recommendations standard of an International Code of Zoological Nomenclature, the current version being ICZN (1999) with electronic publication addendum. The stated aims of ICZN is for "*Standards, sense and stability for animal names in science*" also expressed as "*maximum universality and continuity in the scientific names of animals*".

By convention, the species (its name always in always lower case) is tied to and defined by the state of the unique type-specimen (i.e., the Holotype, Lectotye, or Neotype) that is ideally stored for perpetuity in a recognized institution. [I have been unable to verify that: "*Some countries (e.g. Australia) require that primary type specimens be deposited in collections of the country of origin*" - http://www.mapress.com/zootaxa/author.html]. Perhaps it's just a recommendation.

Similarly, the genus (always with the first letter capitalized) is defined by the characteristics of the named type-species. All specimens that comply with these references, allowing for permissible variation, are attributed to that taxon at each level.

For example, pheretimoid species with nephridia on the spermathecal ducts and male pores in copulatory pouches, as found in the type-species *Pheretima montana* Kinberg, belong in the genus *Pheretima* sensu stricto. (The original author of a species name is put in braces only when the species name is later transferred or associated with other than its initial genus). A colon ":" or semicolon ";" denotes subsequent citations.

Intrasubspecific entities (e.g. 'varieties' or 'formae' or 'morphs'), hypothetical concepts, and vernacular names are outside of nomenclature and have no official status; except in special cases where these names are validly elevated to the ranks of subspecies or species [e.g., ICZN (1999, Art. 45.6.4) allows such names published before 1961, **or validated before 1985**, to assume sub-specific rank]. But the availability of a valid taxonomic name is not affected even if based (initially) on immatures, morphs, castes, partial samples, or parthenogenetic forms (ICZN, 1999: Art. 17.3). Biologically, subspecies are usually regarded as morphologically distinct, potentially or actually interbreeding conspecific populations, whereas a species can be defined as a reproductively isolated, interbreeding population (Mayr, 1969; Sims, 1983: 472). **Sub-generic names**, although listed, are considered by this author to be divisive, adding unnecessary complexity and confusion; most can be safely dispensed with; and ditto for sub-families.

The taxonomic code operates under the '***Principle of Priority***' whereby the valid name of a taxon is generally the oldest name correctly applied to it. Page Priority does not automatically take precedence as the 'First Revisor' may decide a case (except for type species of genera that may have "*position precedence*"). **Homonymy** occurs where the same species name is used for different organisms, although transfer to separate genera removes this. **Synonymy** is where the same organism has been given various names so that only the earliest valid name is correct for that species. **Orthography** is the correct spelling of the names, which may nevertheless change their Latin gender to agree with that of the genus (this problem is avoided where taxonomists use names based on the geographic location or on nouns in apposition). **Misnomy**, as defined here, is the misspelling, misciting or misforming of species/author names and the creation or perpetuation of such misnomers.

Use of Latin may be found on the internet (Ref., Ref.) and Greek → Latin here.

The taxonomist is obliged to immediately correct mistakes from earlier works – their own and those of others. However rigorous, the naming process is an activity of 'convenience', separate from speciation processes at work in Nature and is a

wholly human endeavour. The current writer concurs with ideas that changes in behaviour are precursory to evolutionary change and that, in reality, a species is defined by its ecological associations, behavioural responses, and evolutionary history; the name is merely a unique identifying reference. However, as with any good story, it is important to get the name right.

Quentin Wheeler (2004) eloquently calls for "*Clarity of vision and courage of purpose*" when applying 'Taxonimic Triage'.

Parthenogenetic polymorphism and its problem to taxonomy

Although sexual dimorphism is not known in hermaphroditic earthworms, the three main kinds of morphological variability are a result either of different life stages (i.e., immature, juvenile, sub-adult, adult, regressed adult); or parthenogenetic degradation of reproductive organs, or due to other factors (e.g. aberrations or natural species variability, defective regeneration, and ecotypes:- local genetic variants caused by geographic, climatic, elevational, or soil related factors).

Parthenogenetically degraded morphs that do not reproduce by normal meiosis and cross-fertilization to produce diploid offspring are outside the conventional species concept (e.g. Mayr, 1968; Gates, 1972). Although the availability of a taxonomic name is not affected even if based on morphs or parthenogenetic forms (ICZN, 1999: Article 17.3) it is preferable, however, that these 'events' should be distinguished with scientific names only after considerable research has been conducted to determine the ancestral and presumably amphimixic populations from whence they originate. Moreover, Gates (1972: 95) said that provision of names for all intermediate morphs, including non-sexual feeding 'tubes', of such species complexes is "*ridiculous*".

Gates (1972: 16-19) deduced parthenogenesis in lumbricid or megascolecid earthworms where members of a population, rather than an aberrant earthworm, have these conditions:

(1) testes and/or seminal vesicles retained in a juvenile state in adults;

(2) absence of spermatozoal iridescence in male funnels and/or spermathecae;

(3) lack of spermatophores in species normally bearing these structures, or, if present, absence therein of spermatozoa.

Male sterility in specimens with any or all of the above conditions may be further accompanied by loss or degradation, completely or partially, of other sexual organs,

e.g. genital markings, spermathecae, male copulatory structures, prostates, and modified setae. Thus, only the clitellum, ovaries, oviducts, and perhaps ovisacs, are essential for reproduction. Gatesian codes for common forms of degraded morphs are:

A – for parthenogenetic **athecal** morphs (i.e., lacking spermathecae);

R – for parthenogenetic **anarsenosomphic** morphs (i.e., lacking male terminalia);

Z – for morphs **lacking testes** (also testis sacs and/or seminal vesicles);

AR - athecal, anarsenosomphic, parthenogenetic morphs;

ARZ – athecal, anarsenosomphic, parthenogenic morphs without testes;

I – for **intermediate** morphs with incomplete/asymmetrical deletion of above organs;

Hp – for hermaphroditic parthenogenetic morphs in which the reproductive organs are present but remain in a juvenile state in adult specimens;

H – a **hermaphroditic** morph with biparental reproduction of a species also with parthenogenetic morphs. (Note: a H morph is not to be confused with the Holotype).

Intermediate morphs facilitate recognition of the ancestral amphimictic populations, in which case "*the species is understood to include not only the interbreeding population, but also all recently evolved uniparental strains, clones, or morphs that clearly are affiliated with it*" (Gates, 1972: 18). Where the original biparental population is unknown, or extinct, the intermediates may at least allow taxonomic synonymy of the variously degraded morphs that have been given species names precipitously. Parthenogenic morphs may yet copulate (e.g. pseudogamic reproduction with or without exchange of sperm) and polyploidy is not essential for parthenogenesis as some male sterile diploids are known (Gates, 1972: 61, tab. 1a; Ref). Ljungström (1970) lists families and Edwards & Lofty (1977: 61) list North American species claimed to be parthenogenetic. Sims & Gerard (1985; 1999: 82) state that *Eisenia fetida* may have spermatophores and be facultatively self-fertilizing when in isolation. The functional anatomy of the reproductive organs, especially of the spermathecae and prostates, and their general importance in earthworm systematics are described in Blakemore (2000e) and outlined in a preceding section.

Systematics

Lee (1970) stated that traditional taxonomy attempts to fulfill three requirements:

(1). To assign exclusive and universal names to species.

(2) To establish a hierarchy of taxa above the species level that can be described in mutually exclusive terms so that they may be placed and ranked by the non-specialist. (3). To show evolutionary and biogeographic relationships between taxa (systematics).

He noted that these first two requirements, mandated by ICZN codes, are often incompatible with the third. Moreover, the simple, codified rules of nomenclature (e.g. for correct formation and spelling of names) are not the same as the inherent and simple rules of biology (in the terms of Occam's Razor) for which our minds can comprehend only an elementary knowledge or understanding of the resulting tendency to complexity.

Linnaean / Binomial taxonomy vs. Cladistics - also called ***Phylogenetic Systematics*** or ***Phylogenetic Taxonomy***

Classification and 'Cladification' are not the same processes. Reconciling a Linnean/evolutionary/systematic classification scheme with Cladistics is often impractical, if not impossible, due to different basic assumptions as noted in the Preface to the latest Code (ICZN, 1999) where it says:

"*The conventional Linnaean hierarchy will not be able to survive alone: it will have to coexist with the ideas and terminology of phylogenetic (cladistic) systematics. From a cladistic perspective, our traditional nomenclature is often perceived as too prescriptive and too permissive at the same time. Too prescriptive, in so far as it forces all taxa (and their names) to fit into the arbitrary ranks of the hierarchy; too permissive, in so far* ***as it may be equally applied to paraphyletic as to monophyletic groups.***" [My bolding added for emphasis].

This argument is succinctly put on Alan Kazlev/Toby White's *Palaeos* website by Dr R.K. Brummitt [palaeos.com/Systematics/Cladistics/incompatable.html July, 2005]:

> "*Linnaean classification without paraphyletic taxa is a logical impossibility. Every monophyletic genus in a Linnaean classification must be descended from something (probably a species) in a different genus, which must be paraphyletic. Similarly every monotypic family must be descended from a species in a genus in a different family. If one denies paraphyletic taxa, where do genera and families come from? Ultimately, one would end up sinking everything into its ancestral taxon, and the*

whole classification would telescope into its original taxon... " and...

"*The theory of a Linnaean classification without paraphyletic taxa is nonsensical. Hennig's proposal to eliminate paraphyletic taxa [from Cladistic studies] was based on a failure to see the difference between the Linnaean hierarchy in which all taxa are nested in the next higher taxon, and a phylogenetic hierarchy which is not so nested, the lower levels of the hierarchy being not equivalent to the higher levels.* ***Put another way, all the species of a genus together equal the genus but all the offspring of a parent do not equal the parent***." [My bolding].

Paleontologists have found a solution – conceding that paraphyly is another version of monophyly so that monophyletic taxa can be either holophyletic (= monophyletic *s. strict*), or paraphyletic (Valentine, 2004). See also discussions in Mayr (1995; 1998), Wheeler (2004, 2007, 2010), Padian (2004 with repudiation in Stamos, 2007), Blakemore (2005), Schmeltz & Timm (2007 - who also cite Blakemore, 2005) and, for the situation with plants – see Zander (2008).

The fundamental differences between the approaches of "*Hennigian Cladistics*" vs. "*Darwinian Classification*" is discussed in detail by Ernst Mayr (1998) and Mayr & Walter J. Bock (2002) – who favoured of a combination of morphological and molecular studies using Linnaean systematics (as advocated here). Incongruity between cladistics and taxonomic systems, especially for plant systematics, is reviewed by Grant (2003), and Mayr & Bock (2002) who said:

"When the molecular methods were first introduced, some authors thought that these were automatically superior to morphological characters based on subjective evaluations. But different molecular methods also often led to different results, and it was eventually realized that different molecules may have different rates of change (mosaic evolution) and that morphological characters, the product of large numbers of genes, are usually quite reliable."

Mayr & Bock's definitions are for 'Darwinian Classification':- "*A classification based on two criteria – similarity and common descent*", plus we might add "and often proximity"; and for 'Hennigian Cladification':- "*An ordering system .. arranged with reference to the sequence of the branching points .. based on the principle of holophyly*" and they clearly define 'holophyly' in its restricted Cladist sense.

Evolutionary trajectories from both systems are complementary rather than independent, and paraphyletic taxa have value to each, so that either can be useful

depending upon the question you are trying to answer; moreover, both systems roundly reject polyphyletic groups, i.e., those sharing derived characters obtained via non-homologous convergence ('homoplasies'), as being "*invalid and unnatural*".

Much breath and ink is pointlessly expended on trying to reconcile the two systems and often the same taxonomic concept has different meanings under one scheme or another. Attepts at resolution via molecular methods are invalidated when types are avoided and, similarly, so-called "*cryptic species*" (defined as morphologically similar but genetically distinct sibling species) are pointless without priority of synonymy. Types, even if formalin preserved or dried, may yet allow PCR amplification, at least in 44% of cases using current technologies, that will undoubtedly improve with time (Ref1., Ref2), the latter Ref uses non-desructive DNA sampling via immersion of dried museum beetle specimens up to 50 years old.

The current work treats Linnean systematics as codified by ICZN (1999) that ignores hypothetical concepts of classification at or above the family level, the primary concern pragmatic:- the correct identification and naming of a species via systematic (heuristic and empirical) methods, with a realization that not all members of a (monophyletic) group may be accounted for due to extinction or oversight. All classification depends on a correctly observed specimen of a tangible species whereas genera and families are hypothetical concepts as are higher classifications that are, however, uncodified and anarchic. It is necessary, nevertheless, to briefly consider higher classification, for which species are the most 'convenient' elements of construction, to better understand the relationships between groups. A recent topic for discussion of a colleague, Dr Tarmo Timm (Ref.), stated:

"*We should not abandon a traditional, nominal taxon at once when it appears to be paraphyletic. In particular, the recent trend to replace the taxon* ***Oligochaeta*** *with* ***Clitellata*** *everywhere is impractical. Biologists use (and will continue to use) paraphyletic taxa (grades, instead of clades) on the highest levels of hierarchy: e.g., the Bacteria, Eukaryotes, Protista, Platyhelminthes. The nominal classes of Amphibia and Reptilia will survive in everyday use, although being* ***paraphyletic.*** *Accumulation of phylogenetic information should change the more vague "cladistic" system* ***instead of*** *the Linnaean system and nomenclature, required in all branches of biology*."

My personal suggestion would be to provide a dual system with a superimposed and logical relational database Knowledge Retrieval Schema, such as the Dewey Decimal System as used in most libraries that allows a book to be logically classified as well as to hold a Title (= scientific name) and Author, and covering all of life on Earth.

Thus all Biota i.e. Bacteria, Archaea, Protista, Fungi, Flora and Fauna, would be united under an heirarchical and phylogenetic schematic while retaining their Scientific names and allowing any subsequent categories to be appended or intergrated. The proposed and controvertial Phylocode apears to attempt a similar thing in a more difficult way.

Pertinent to this debate is the increasing importance, potential and misuse of genetic information to propose or resolve hypothetical phylogenies. This science it still in its infancy (what we knew just 5 years ago seems so dated and basic nowadays, as will our current state of knowledge in the succeeding decades). Thus it seems imprudent to lash ourselves to the mast of any particular topical theory based on such a recent technological understanding. There will be proven solutions in time, but the best option at present is to tread cautiously and to take dogma with the healthy skepticism it deserves.

Haploid genome sizes (C-values) from 15 spp of megadrile earthworms (Gregory & Herbert, 2002 *Can. J. Zool.*. **80**: 1485-1489) varied from ~0.4 to 1.2 pg - one picogram equals 978 megabases (Dolezel *et al.* 2003). Statements on technological progress of molecular microsatelites and other genetic/genomic methods for identification of (mainly lumbricid) species are by Pop *et al.* (2008 – see Table below) and Dupont (2008). However, this science is in its early days and determinations entities such as "*cryptic species*" must be taken with caution within the context of ICZN priority (see Blakemore *et al.*, 2010).

The criterion proposed by Hebert *et al.* (2004) for a new species delimitation is when average divergence between the reference species and a newly discovered putative sibling species is >10 times the average divergence found within the species; for different bird species, a threshold of 2.7% was indicated. COI values differing by averages of ~4–10 % are found acceptable to separate species level taxa in invertebrates (Ref.), thus actual differences of 2-3% of COIs may be a reasonable threshold value. The Blast program can be used to determine these %'s and to check the Genbank library (but caution is needed with interpretation due to rampant species misidentifications).

Cryptic sibling-species were first considered by Mayr (1948, 1996) but current proponents – often molecular technicians acting like "*taxonomic tourists*" according to Blakemore (2010) – who ignore a taxon's prioritized synonyms are not at all helpful.

Nevertheless, the only viable future for taxonomic progress is rapid DNA analysis. Regarding type specimens of species, these are the possible outcomes:-

Contingency table of DNA barcoding of type specimens to define species

Morphological Species	Types spex	Sample DNA	MolecularResult

Known (named)	Old, present and usable	From lectotype (if successful)	Confirm species/synonym
Known (named)	Old, present but not usable	From fresh topotypes	Confirm species/synonym
Known (named)	Absent or lost	From neotype and/or topotype	Confirm or "kidnap" species
New	New	From holotype	Compare species/morphs

While offering the only plausible hope for identifying parthenogenetic components of species-complexes, juveniles or partial animals, such GENOMIC studies are meaningless and ungrounded without initial testing and definition of tissue samples from type-specimens (plus progressive analysis of the synonymic types too), or alternatively from topotypic 'avatars'. Ditto generotypes (type-species of a genus) and ditto type-genera of families.

The suitability of some markers is summarized here:

Molecular marker usefulness at taxonomic levels from Pop *et al.* (2008: 205, tab. 1):

Marker	**Origin**	**Usefulness**
EF-1a +	ncDNA	Used for deep level questions such as Annelida origin
18S rDNA	ncDNA	"Deep" phylogenies for higher level taxa
28S rDNA	ncDNA	- partial sequences too variable for good signals - complete sequences more informative than 18S
16S rDNA	mtDNA	Useful for intraspecific and intrageneric levels
ITS	ncDNA	Rapidly evolving region useful for closely related species
COI + *	mtDNA	Useful for population, subspecific or close species levels

*COI is mtDNA, mitochondrial cytochrome-c oxidase subunit1 gene, a *de facto* standard (Ref.) as ratified by the Consortium for the Barcoding of Life (CBOL), although (Pop *et al.*, 2007) confirmed that the COI gene gives highly variable information often in disagreement with that of the 16S but still suitable for revealing phylogenetic relatedness in closely-related species or in species complexes.

Pop *et al.* (2007), Blakemore (2009), and Sturzenbaum *et al.* (2009) provide some historical and predictive information on earthworm genome research, starting with Darwin's classical studies. Blakemore *et al.* (2010) and Blakemore (2010) model and exemplify mtDNA COI gene barcoding based on ICZN types for the first time for an earthworm species. Blakemore (2012) and Blakemore *et al*. (2014) provide descriptions for several new and known molecular species in families Moniligastridae, Acanthodrilidae, Megascolecidae and Lumbricidae.

Family Classification of Earthworms

Earthworms under consideration here are mainly terrestrial members of the Annelida Lamarck, 1802 : Oligochaeta Grube, 1850 that are sometimes placed in Superorder Haplotaxidea, i.e., orders Moniligastrida plus Opisthopora Michaelsen, 1928 (= Lumbricina DeBlainville, 1828) – but just the Megadrilacea components. Lamarck (1802: 24) first defined the Class as "*Annélides*" but some authors attribute it to "Lamarck, 1801" or "Lamarck, 1809" and Grube's Oligochaeta is either at Class or Order rank depending on author (see discussion by Gates, 1962: 298-299).

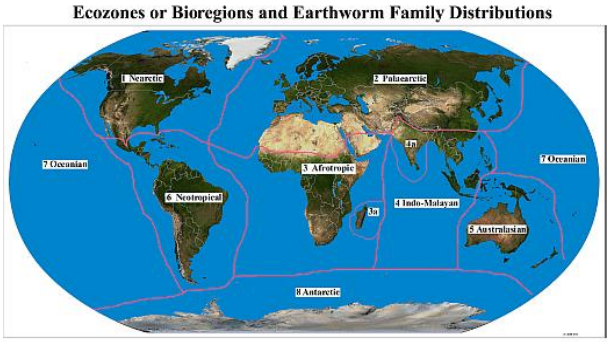
Earthworms and freshwater worms, are deliminated by Claparede's (1862) use of Örsted's (1843) terms '**Terricolae**' and '**Limicolae**' which Rosa (1882) and Vejdovsky (1884) divided into ~17 families, the latter 9 of which correspond to the **Megadrili** Benham (1890: 218) that naturally includes the Moniligastridae; i.e., a prior epithet than terrible "*Terrimegadrili*" or crass "*Crassiclitellata*" (?= Lumbricina DeBlainville, 1828), or some such, that excludes them. Because some authors persist in using these restrictive terms erroneously, Blakemore (2013) was obliged to construct Exquisiclitellata to accommodate megadriles such as Moniligastridae with single-celled clitella, although this too is encompassed by Megadrilacea. Sims (1978) and Easton (1981: 33) and Blakemore (2013) described the Megadrile (i.e. all terrestrial earthworm) species in Class/Order '**Megadrilacea**' from Benham (1890: 218) that seems to have priority to these later, non-inclusive names.

The Class (Superorder?) Oligochaeta Grube, 1850 is frequently used interchangeably with Subphylum Clitellata Michaelsen, 1919 [defined by him as the Oligochaeta plus the Hirudinea (leeches) also confirmed by Siddall *et al.*, (2001) who favour Oligochaeta over Clitellata, or Staton (2003) from molecular/cladistic studies - see discussion by Gates (1962: 298-299)]. Especially workers on smaller, aquatic and less important '**microdrile**' (Microdilacea) groups tend to use "Clitellata" but these are excluded in the current account, even though taxa such as the Enchytraeidae (with just ~700 species) also contain terrestrial members.

Terrestrial **megadrile** earthworms number approximately 7,000 named taxa (Blakemore, 1999, 2000; Cs. Csuzdi, 2003; Blakemore, 2008, 2010, 2013). Many more species have yet to be identified, whereas innumerable synonymies and/or cryptics may be found for those already described. For example, the *Pheretima*-group of genera consisted of 860 nominal species for which Sims & Easton (1972) and Easton (1979) thought about half were valid. Indeed, Blakemore (2004, 2005; 2007) has compiled a

revised checklist of about 920 valid pheretimoid taxa from ~1,400 named species. Recent systematic revisions of World Families are by Sims (1980), Reynolds & Cook (1993) and Blakemore (2000e; 2002; 2007, 2008, 2010, 2013) which all retain Acanthodrilidae separate from Megascolecidae, but each with somewhat different definitions and none as practically correct as Blakemore (2000) that maintains megascolecids with tubular prostates in Megascolecidae (unlike other failed "Gatesian" systems that separate all tubular prostate species into Acanthodrilidae!). To check, try to use their unworkable keys to families (although most poor authors fail to provide these).

Here is my current synopsis of the Megadrile Earthworm Families (after Blakemore, 2000, 2006, 2013, 2014): **1 Moniligastridae 2 Ocnerodrilidae (inc. Malabariinae) 3 Acanthodrilidae *sensu* Blakemore, 2000 (?inc. 3a Diplocardiinae, 3b Maheinae 3c Wegeneriellinae) 4 Octochaetidae (inc. 4a Trigastrinae, 4b Benhaminae 4c Typhoeinae 4d Hoplochaetellinae) 5 Exxidae 6 Megascolecidae *sensu* Blakemore, 2000 (inc. ten subfamilies after Blakemore, 2013) 7 Kynotidae 8 Microchaetidae 9 Tritogeniidae 10 Eudrilidae (inc. Polytoreutinae) 11 Hippoperidae 12 Almidae 13 Criodrilidae (?inc. Biwadrilidae) 14 Hormogastridae (? inc. Ailoscoledicae) 15 Ailoscolecidae (?inc. Komarekionidae) 16 Sparganophilidae 17 Lutodrilidae 18 Lumbricidae 19 Glossoscolecidae 20 Tumakidae.**



Ecozone (Bioregion): 1 Nearctic 2 Palaearctic (1+2 = Holarctic) 3 Afrotropic (Ethiopian) 3a Madagascan (Malagasy) 4 Indo-Malayan (Oriental) 4a Indian 5 Australasian 6 Neotropical 7 Oceanian 8 Antarctic

Megadrile Earthworm Families (after Blakemore, 2000, 2006, 2013, 2014): 1 Moniligastridae 2 Ocnerodrilidae (inc. Malabariinae) 3 Acanthodrilidae sensu Blakemore, 2000 (?inc. 3a Diplocardiinae, 73b Maheinae 3c Wegeneriellinae) 4 Octochaetidae (inc. 4a Trigastrinae, 4b Benhaminae 4c Typhoeinae 4d Hoplochaetellinae) 5 Exxidae 6 Megascolecidae sensu Blakemore, 2000 (inc. ten subfamilies after Blakemore, 2013) 7 Kynotidae 8 Microchaetidae 9 Tritogeniidae 10 Eudrilidae (inc. Pareudriinae & Polytoreutinae) 11 Hippoperidae 12 Almidae 13 Criodrilidae (?inc. Biwadrilidae) 14 Hormogastridae (?inc. Ailoscoledicae) 15 Ailoscolecidae (?inc. Komarekionidae) 16 Sparganophilidae 17 Lutodrilidae 18 Lumbricidae 19 Glossoscolecidae 20 Tumakidae

1 Nearctic – 1*, 2*, 3*, 3a, 4*, 6, 6*, 10*, 13*, ?14*, 15, 16, 17, 18, 18*, 19*.
2 Palaearctic – 1, 2*, 3*, 4b*, 6 (Far East Asia), 6*, ?10*, 12 (in Egypt), 13, 14, 16*, 18, 18*, 19*.
3 Afrotropic – 1*, 2, 3, 3*, 3c, 4*, 4b, 6*, 8, 9, 10, 11, 12, 18*, 19*.
3a Madagascan – 2*, 3, 4 (Howascolex), 4b*, 6*, 7, 10*, 19*.
4 Indo-Malayan – 1, 2*, 4, 4b*, 6, 6*, 10*, 12, 18*, 19*.
4a India – 1, 2 (Malabariinae), 3*, ?3b, 4, 4b*, 4c, 4d, 6, 6*, 10*, 12, ?13*, ?16*, 18*, 19*.
5 Australasian – 1*, 2*, 3, 4, 4*, 4b*, 6, 6*, 10*, 18*, 19*.
6 Neotropical – 1*, 2, 3, 3a, 3c, 4, 4a, 4b, 5, 6*, 10*, 12, 13*, 16, 18*, 19, 20.
7 Oceanian – 1*, 2*, 3*, 4*, ?4b, 6, 6*, 10*, 18*, 19*.
8 Antarctic – 3, 6*, 18*.
*Present only by accidental/deliberate introduction; (note Acanthodrilidae absent from India & Asia).

Figure of World Ecozones or Bioregions & Distribution of Earthworm Families after Blakemore (2000, 2013, 2016) (incl. exotic introductions). [Full size here].

Comparison of Various Family Classifications (non-specialists may skip this section)

The most recent revision of world families is by Blakemore (2000, 2002, 2005; 2006, 2007, 2013). Previous treatments of the megadrile Oligochaeta by Sims (1980, 1982) appeared to have been widely accepted (see Parker, 1982: 50-61; Easton, 1980: 35; Easton, 1984: 111; Sims & Gerard, 1985: 41; etc.) but were found wanting. Sims' system built on his earlier computer analysis (Sims, 1966) as well as the prodigious contributions, spanning almost 60 years, of Gates (e.g. Gates, 1925; 1959; 1972; 1982). Yet, most subsequent phylogenetic works owe much to Michaelsen's influence (see Lee, 1994), and to the "***Classical System***" - defined by Gates (1972) as that devised and presented by Michaelsen (1900) in *Das Tierreich*, and expressed in its final form by Stephenson (1930) in *The Oligochaeta*. Although Michaelsen (1921, 1929) had revised his earlier classification, Stephenson (1930) reverted to that of the *Tierreich*, and therefore 1900 is the date that heralded a period of structure and stability to earthworm systematics. Other taxa proposed during this period Gates (1972) classed as "*neoclassical*". In the last 40 years, however, the details of the arrangement and components of the families, particularly the composition of the Megascolecidae, have become the subject of much debate, controversy, and a continuation of what Gates (1959: 252) termed "*reshuffling based on the literature*"; or as: "*Much breath & paper has been largely wasted arguing the appropriate rank of a group*". [http://www.palaeos.com/Systematics/Cladistics/incompatable.html 2005].

Michaelsen (1924) had a Megascolecina, (Order or Superfamily?) comprising Acanthodrilidae and Megascolecidae at least, and while Lee (1959) had recognized Stephenson's definitions of families and divided the Megascolecidae into two subfamilies: the Acanthodrilinae (including the Octochaetinae) with an 'acanthodriline' form of male and prostatic pores, and the Megascolecinae with the 'megascolecine' arrangement i.e., one pair of male and prostatic pores combined on 18 (and either tubular or 'non-tubular' prostates). Gates (1959, 1972, 1976), a constant critic of the classical system, rejected Lee's system, and proposed a revised (here shown to be flawed) scheme in partial agreement with Michaelsen (1921, 1929) which was presented in a refined form by Sims (1980, 1982). Gates falsely allowed only 'truly' racemose prostates in the Megascolecidae and all other excluded species - "*with tubular glands, regardless of presence or absence of lateral branches from the axial lumen*", went into the (holoic) Acanthodrilidae and (meroic) Octochaetidae. Yet

another flawed scheme was contrived by Jamieson (1971 and subsequently), largely ignoring different forms of prostate, based instead on a false syllogism that allowed a relatively few actually instances of detailed descriptions of nephridial arrangements to account for placement of whole groups. This scheme was criticised in whole or part by several authors around the world and is presumably rejected by anyone who correctly cites "*Acanthodrilidae*" or "*Octochaetidae*" (e.g. Reynolds & Cook, 1976, 1981, 1993; Edwards & Lofty; 1977; Easton, 1979: 9, 17-20; Sims, 1980; 1982a; 1982b; Easton, 1984; Sims & Gerard, 1985, 1999; Fender & McKey-Fender, 1990; James, 1991: 339; Julka, 1988: 5, 368; Csudzi, 1996; Wetzel, 2003, 2005; etc., etc...). Rejection is due partly to its being based on *negative* (i.e., absent) or on seemingly adaptive ultrastructural characteristics of the nephridial system which are not only difficult to demonstrate (especially when they are absent!) but which Easton (1979: 17) also showed to be hampered by the paucity of available information for most species; and due partly to biogeographical anomalies (e.g. Sims, 1980: 105; 1982: 284). Moreover, because the finer nephridial details of most species described from around the world are not known, and because determination of such details would now be difficult, if not impossible, to obtain (see Gates, 1959: 252; 1972: 24; Easton, 1979: 9), this scheme is impractical, did little to provide clarity, and was also found to have gross morphological groupings that were not mutually exclusive (Blakemore, 1994a: 225-231). Eventually, after 30 odd years, it was agreed to – even by Jamieson (2000) and Jamieson in Dyne & Jamieson (2004)! – that his sub-familiar divisions were "*obsolete or restricted*" being based on "*highly homoplastic apomorphy of meronephridia*"- which is what I had been saying for 10 yrs from Blakemore (1994).

So, after all this diversion and distraction (= waste of time and ink/pixels), we can now return to explore the more reliable and workable options that had been proposed in the previous ***Classical System*** one Century before. The pragmatic, justifiable and tautological rationale behind the current generic and family reviews, based on the principles and spirit of the Classical System, is quite simply that any derivation from a plesiomorphic character state (i.e., known to occur in 'primitive' taxa), is regarded as a derived apomorphy. Thus, tubular prostates (i.e., gland elongate with simple unbranched central canal), holoic nephridia (i.e., two per segment) and lumbricine setae (i.e., eight per segment) are considered plesiomorphic/primitive (e.g. see Michaelsen, 1900; 1907; Stephenson, 1930; Blakemore, 2000); anything else is obviously a derivation.

I endorse the view of Stephenson (1923: 316) who said "*one of the great features in the evolution of the Megascolecinae has been the change in the prostate; and if this in not to be marked in our scheme of classification, the scheme will be comparatively useless; it will certainly fail to indicate what it ought*". But I again stress that the natural division argued for by Blakemore (2000, 2002), after resolution of male pores, was for species with prostates that are either tubular (plesiomorphic) or "***non-tubular***" (apomorphic), but this is important at higher taxonomic levels only for membership of Exxidae (i.e., 'exxidine' spp) separate from Octochaetidae and is currently irrelevant for subdivision within Megascolecidae s. stricto separate from Plutellinae/Pontodrilinae Vejdovsky, 1884, pending the latter's resolution.

The main advantage of Gates' otherwise flawed scheme was the pragmatic and '*convenient*' elevation of the Ocnerodrilidae, Acanthodrilidae, Octochaetidae, and Megascolecidae to family rank (perhaps comprising a superfamily Megascolecina?), although his actual definitions were askew. Yet one exceptional and "*troublesome*" species, *Exxus wyensis* Gates, 1959, disrupted an otherwise workable templet. This meroic species with an acanthodriline arrangement of male and prostatic pores complied with the Octochaetidae but, because it had racemose prostates, Gates (1959: 258) allowed it to introduce the acanthodriline state into his redefinition of the Megascolecidae, whereas Jamieson (1971) allowed it to introduce racemose prostates into his redefinition of the Acanthodrilidae. Neither of these unnatural options is acceptable in Nature, nor herein. Hence the need for extensive review and revision by Blakemore (1994, 2000, 2013).

Thus the suborder Lumbricina contained from 7 to 21 families under various classifications (e.g. Benham, 1890; Edwards & Lofty, 1977; Reynolds & Cook, 1976, 1993; Sims, 1980; Blakemore, 2000, 2013). Under the "*Classical*" system of Michaelsen (1900, 1920 and 1928), which was expressed in a refined form by Stephenson (1930), the 'megadrile' section, consisting of earthworms and their aquatic relatives (corresponding to the suborder Lumbricina) included seven families. The Megascolecidae consisted of Acanthodrilinae, Megascolecinae, Octochaetinae, Ocnerodrilinae and Diplocardiinae. Gates (1959, 1972) elevated four of these subfamilies to family status (all except the latter) and placed an emphasis on the nature of the prostatic glands, just as, 50 years earlier, Michaelsen (1907) had considered prostates as primarily important characters. Michaelsen (1920) had already elevated Acanthodrilidae to family level status (with sub-families Acanthodrilinae, Octochaetinae,

Diplocardiinae, Trigastrinae and Ocnerodrilinae), separate from Megascolecidae according to Stephenson (1923: 37-38). Such moves were largely supported by Sims (1966, 1980) who ultimately advocated Ocnerodrilidae, Megascolecidae, Acanthodrilidae and Octochaetidae as separate. Reynolds & Cook (1981; 1989: 1; 1993) maintained Acanthodrilidae, Octochaetidae, and Megascolecidae (but with definitions different to those proposed by Blakemore, 2000). These authors also cited a dubious family "*Diporochaetidae*" (actually a lapsus for Lumbricidae (sub-)family Diporodrilidae Bouché, 1970), and they added Lobatocerebridae Rieger, 1980 (misspelt and misattributed as "*Labatocerebridae Reiger*") that is a Polychaeta (!).

Monotypic Syngenodrilidae (or Syngenodrilinae) is usually accommodated in Alluroididae (as per Gates, 1959), or both are retained under superfamily Alluroidoidea, the only microdrile group that Reynolds & Cook (1976: 2) place under Lumbricina.

In revisions of the Octochaetidae, Csuzdi (1996, 1997, 2000) re-established three sub-families of Acanthodrilidae comprising an holoic Acanthodrilinae Claus, 1880, and meroic Octochatinae Michaelsen, 1900 plus Benhamiinae Michaelsen, 1895 with this last sub-family having 2-3 pairs of extramural Ca glands beginning after segment 14. Note that Csuzdi (1995: 100; 2010: 105) weakly defines Benhamiinae on either "*several*" or on "*Two pairs of stalked extra-mural calciferous glands present in segments 14–15*". Blakemore (2000e) did not consider these latter changes, but revised and redefined concepts of Acanthodrilidae and Megascolecidae to maintain both separately depending primarily on the forms of the male pores and reproductive organs, and secondarily on the type of nephridia, while extracting from the Octochaetidae (or other families where it had been summarily submerged by disparate authors) a new Neotropical family Exxidae. However, it is accepted that some definitions of Octochaetidae may be polyphyletic, perhaps requiring restriction to the New Zealand and Australian type-genus *Octochaetus* Beddard, 1893 (see Blakemore, 2004f; 20f05) and other allied genera; possibly with subfamily Benhamiinae Michaelsen, 1895/7 meriting elevation to family level status. Conversely, cladograms for Oligochaeta miss a third dimension, i.e., locality through time, such that ancient Acanthodrilidae groups that are widely dispersed by vagaries of Continental drift will have diverged independently giving rise to Octochaetidae, but they would still be classed as monophyletic as the common ancestor is shared and, moreover, probably the morphological division (holoic → meroic) occurred before the geographical (regardless of the timing!).

Csuzdi & Zicsi (1994: 230) included holoic genera *Pickfordia* Omodeo, 1958 and West African *Wegeneriella* Michaelsen, 1933 (non Amazonian *Wegeneriona* Cernosvitov, 1939) in their subfamily Benhamiinae of Octochaetidae; these taxa (except *Wegeneriona*) actually belong in Acanthodrilidae as redefined by Blakemore (2000, 2002). Csuzdi (1996: 350-351) later redefined Acanthodrilidae to accept either holoic (Acanthodrilinae s. Csuzdi) or meroic (Octochaetinae s. Michaelsen, 1900) states, but this was soon confounded by his rather contrived tribe '*Neogastrini*' Csuzdi (1996: 363; 2000: 76) that allowed either state and is probably not acceptable. Consequently, Csuzdi's Neogastrini genera are re-allocated to either Acanthodrilidae if holoic or Octochaetidae if non-holoic. Futhermore, Csuzdi's (1996: 365) definition of Megascolecidae with only "*racemose prostates*" is superceded by Blakemore (2000) that permits either tubular **or** non-tubular prostates in this family.

In a more recent update, Csuzdi (2010: 105) summarized that:

"*This subdivision was later supported by OMODEO (2000) as well, using the tribus name Neogastracea, however this contradicts the rule of ICZN Article 29.2 stating that the suffix of a tribe name is -ini. On the contrary, BLAKEMORE (2005) hold the position that only the holoic genera should remain in Acanthodrilidae, the meroic genera should be placed in Octochaetidae because they represent advanced grades which "…are often parts of a partially revealed continuum that we classify somewhat arbitrarily into phylogenetic groups on best available information…". However, placing all meroic forms possessing acanthodriline male apparatus in Octochaetidae would result in a polyphyletic "catch-all" family which is unsup-ported here.*"

Nevertheless, Csuzdi's statement, just as with Gates' earlier acceptance that Octochaetidae may be polyphyletic (e.g. Gates, 1959), does not adequately accept that any acanthodriline & meroic species (i.e., Octochaetidae *s.* Blakemore, 2000) **must** have emerged, or descended, or developed, from some precursor and it is difficult to concieve this as anyhing other than an acanthodriline & holoic species (i.e., Acanthodrilidae *s.* Blakemore, 2000). Thus my logic, reasoning, and argument stands.

Other subfamilies that have been variously in part or in whole combined or separated from Octochaetinae are: **Typhoeinae** Benham, 1890 (cf. Typhaeinae illegitimate corr. of Typhoeinae – see Blakemore, 2013); Cryptodrilidae/-inae Beddard, 1890: 236/ 1891), Diplocardinae (sic) Michaelsen, 1899: 241 & Trigastrinae Michaelsen, 1900: 330 (see Michaelsen, 1900; Stephenson (1923: 362, 469; 1930; Gates, 1959: 256). The changes suggested above are allowed for in the system followed

herein (see sub-family refinement in Appendix – here as published by Blakemore, 2013).

Vandalism.

Despite the above detailed description of revised families, despite Blakemore (2000) making a detailed review, despite this being again published in summary (Blakemore, 2004, 2006, 2008) and put online freely for anyone to read and use (e.g. Blakemore, 2005, 2006, 2007, 2008, 2013), despite all this and more, it seems that there is still ignorant reversion to ill-considered and defunct family schemes. For instance, Buckley *et al.* (2011) who 'relied' on S. James for taxonomy, reverted with no good reason nor explanation to "*Acanthodrilinae and Megascolecinae*" and ignored Octochaetidae. Ditto for James and Davidson (2012) that was critically reviewed by Blakemore (2013).

This would not be such a major concern outside of New Zealand or USA except that some students and other innocent future workers may unwittingly cite these reviews as being sensible, valid and correct. That they aren't is clearly evident when it is soon realized that their species and genera names are confused or wrong too, along with their families. Thus, as with many preceeding molecular phylogenies, and probably many to follow, regardless of the quality of the work, often the only detraction from otherwise excellent conclusions is they have in fact made only one mistake:- that the correct identity of the samples on which the whole study is based.

Case in point with the authors of this effort (Ref.) that, as with many others, was an excellent study except for this one thing – they got the names wrong.

And so the need to invoke, yet again, for "***Standards, sense and stability*** *for animal names in science*" also expressed as "*maximum* ***universality and continuity*** *in the scientific names of animals*", as mandated for by ICZN, that should be implemented to smite the vandalism of all such temporary and selfish "Taxonomic Tourists".

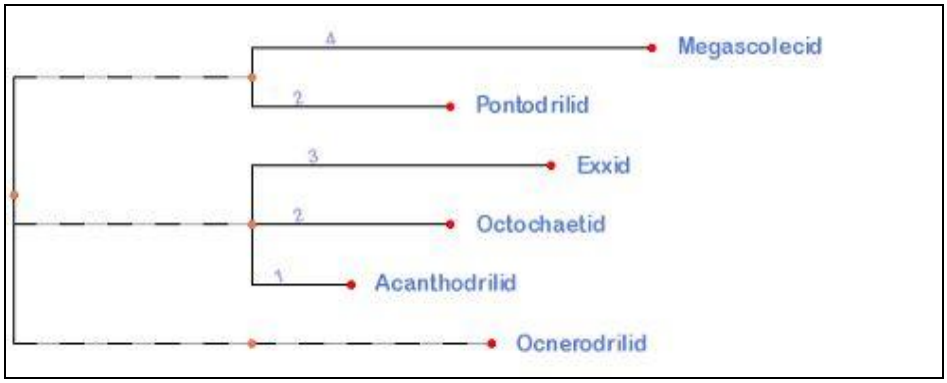
Phylogeny of Acanthodrilidae, Octochaetidae, Exxidae, & Megascolecidae revisited with recourse to non-molecular means – a Summary of Results

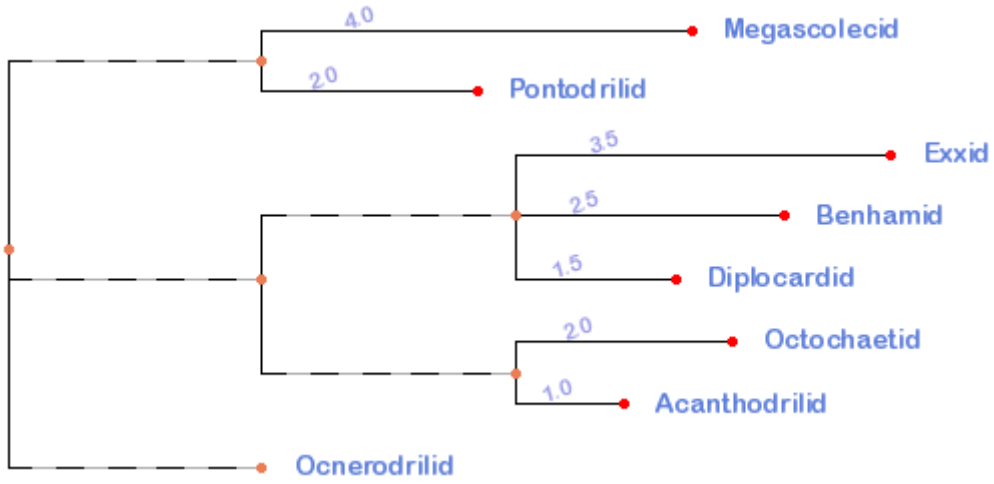
"*A Darwinian classification, by using two criteria, similarity and common descent leads to the recognition of classes (taxa) of similar entities*.." ... "*..almost any method of weighing is preferable to using unweighed characters*"..."*..morphological characters, the product of large numbers of genes, are usually quite reliable*" - Ernst Mayr & W.J. Bock (2002: http://www.blackwell-synergy.com/servlet).

Key morphological characters - the product of ecological interactions and evolutionary time and expressed by combinations of genes, as found in type-species of type-genera of the families in the title are compared via weighting on basic characters in the more 'primitive' Ocnerodrilidae. Phylogenic position is attributed to similarity (or rather dissimilarity) and descent (or rather ascent), regardless of geographical proximity. Re-analysis again shows the Megascolecidae diagnosed only by its derived, non-acanthodriline male field, irrespective of any other character. Moreover, it is newly resolved into a sub-family with tubular prostates (and holoic nephridia), as found in tribe Argilophilini, (type American *Argilophilus marmoratus ornatus* Eisen, 1893: 253 – see Eisen, 1894, Michaelsen, 1921) proposed (including meroic *Driloleirus*) by Fender & McKey-Fender (1990) - although this name competes for priority with Vejdovsky's (1884: 63) resurrected Pontodrilidae and Plutellidae as supported by Eisen (1894: 55) [types Indo-australasian *Pontodrilus marionis* Perrier, 1874 (= *litoralis* Grube, 1855) and Australian *Plutellus heteroporus* Perrier, 1873, respectively]. Although this latter is a homonym of Plutellinae/-idae for lepidopteran *Plutella* Schrank 1802 (diamondback moths). The residue of megascolecid species comply with sub-family Megascolecinae having derived non-tubular prostates (as for the Indian type *Megascolex caeruleus* Templeton, 1844). Further, secondary and subordinate division may be 'convenient' within these two sub-families on basis of such features as holoic vs. non-holoic nephridia or lumbricine vs. non-lumbricine setae (e.g. **Perionycidae** Benham, 1890) and see Blakemore (2013). Due possibly to the "*well known dependence of the conformation of the alimentary tract on food and environment*" (Stephenson, 1930: 720), the position within Octochaetidae [type N.Z. *Octochaetus multiporus* (Beddard, 1885)] of sub-family Benhamiinae, currently defined by its arrangement of calciferous glands, is not fully resolved; and neither is the status, validity nor extent of the polygiceriate Diplocardiinae (type *Diplocardia communis communis* Garman, 1888) sub-family of Acanthodrilidae (type New

Caledonian *Acanthodrilus ungulatus* Perrier, 1872). Support for the current phylogeny, using weighted morphology, is that the resulting tree (shown below) is an almost perfect fit for that pertaining to molecular analyses from Blakemore (2005: Fig. 1), with addition of the Exxidae (type *Exxus wyensis* Gates, 1959). Strict comparisons yet require DNA or barcode testing, ideally from (a small tissue sample) from the type-specimen, or neotype, of the type-species of the type genus of each of the (sub-)families (cf. Huang *et al.*, 2007).

Phylograms from basic morphological characters (tabulated below) of type-species compared to molecular cladogram, not necessarily from type-species:





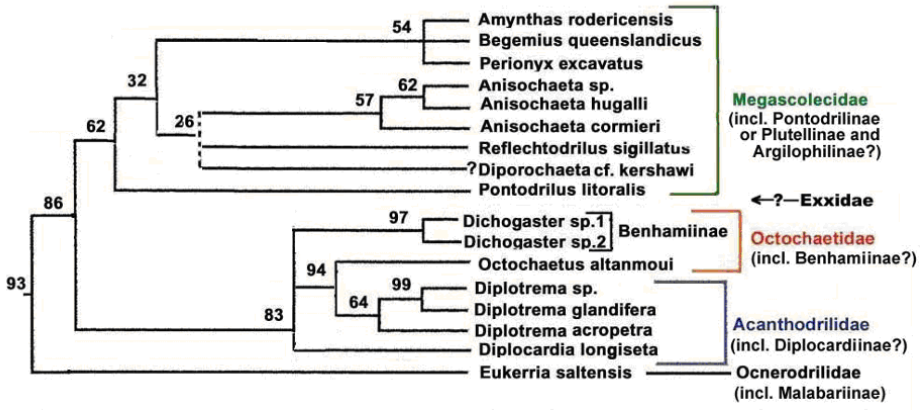
Two alternative phylograms (above) composed from Fredslund, J. (2006). PHY·FI. *BMC Bioinformatics* (2006, **7:** 315. http://cgi-www.daimi.au.dk/cgi-chili/phyfi/go) from weighted data of type-species (in tables below), compared to molecular cladogram, not necessarily from types, (Fig. 1 below from Blakemore, 2005). Unlabelled nodes in phylograms above represent hypothetical, extinct or undiscovered ancestors. Note position of *Pontodrilus litoralis* with respect to Megascolecidae and

the possibility of restoring Pontodrili-nae/-idae Vejdovsky, 1884.

Taxa / Characters:	Hts >11	Non-acantho	Non-tubular	Non-holoic	(Sub)Family	WEIGHT
Ocnerodrilus occidentalis Eisen, 1878	0	0	0	0	OCNERODRILIDAE	0
Acanthodrilus ungulatus Perrier, 1872	1	0	0	0	ACANTHODRILIDAE	1
Octochaetus multiporus (Beddard, 1885)	1	0	0	1	OCTOCHAETIDAE	2
Exxus wyensis Gates, 1959	1	0	1	1	EXXIDAE	3
Pontodrilus litoralis Perrier, 1874	1	1	0	0	PONTODRILINAE	2
Megascolex caeruleus Templeton, 1844	1	1	1	1	MEGASCOLECIDAE	4
					Weighting:- 0 = old; 1 = new.	

Taxa / Weighted Characters	A	B	C	D	E	Total W	(Sub-)Family
Ocnerodrilus occidentalis Eisen, 1878	0	0	0	0	0	0	OCNERODRILIDAE
Acanthodrilus ungulatus Perrier, 1872	1	0	0	0	0	1	ACANTHODRILIDAE
Octochaetus multiporus (Beddard, 1885)	1	0	0	1	0	2	OCTOCHAETIDAE
Diplocardia communis Garman, 1888	1	0	0	0	0.5	1.5	DIPLOCARDIINAE
Benhamia rosea Michaelsen, 1889	1	0	0	1	0.5	2.5	BENHAMIINAE
Exxus wyensis Gates, 1959	1	0	1	1	0.5	3.5	EXXIDAE
Pontodrilus litoralis Perrier, 1874	1	1	0	0	0	2	PONTODRILINAE
Megascolex caeruleus Templeton, 1844	1	1	1	1	0	4	MEGASCOLECIDAE

Table of Key characters weighted for type-species within Megascolecoidea family-group each given their originally taxonomic rank. Characters: **A**, calciferous glands absent or in other than just segment 9 (plus last hearts in segments >11); **B**, non-acanthodriline male pores; **C**, non-tubular prostates; **D**, non-holoic nephridia; **E**, non-polygiceriate; **W**, Weighting: 0 = ancestral/absent; 1 = derived/present (0.5 – classification value uncertain / subordinate).



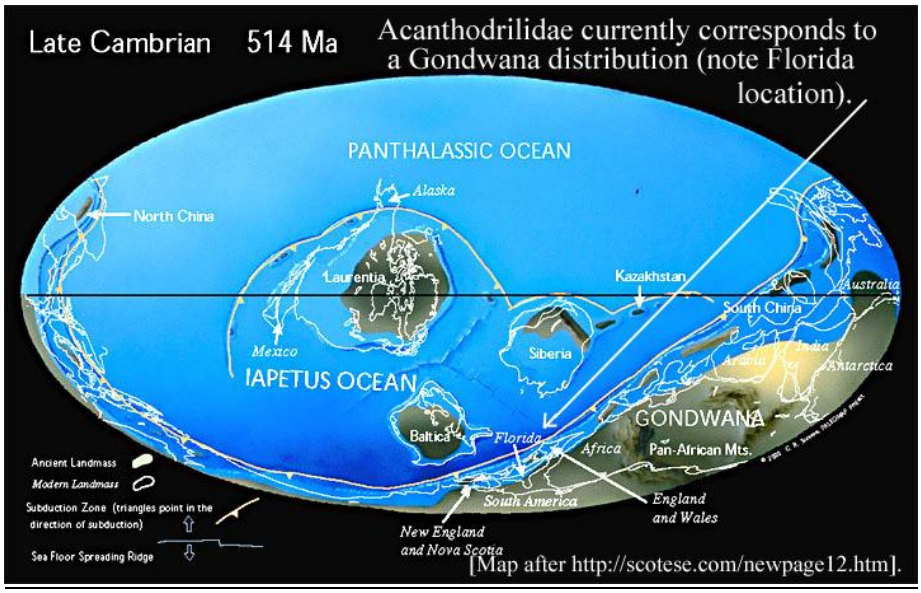
Phylogram from molecular analyses, not of types, after Blakemore (2005: fig. 1); (see sub-family refinement in Appendix – here).

Family Origins and Dispersal due to Plate Tectonics

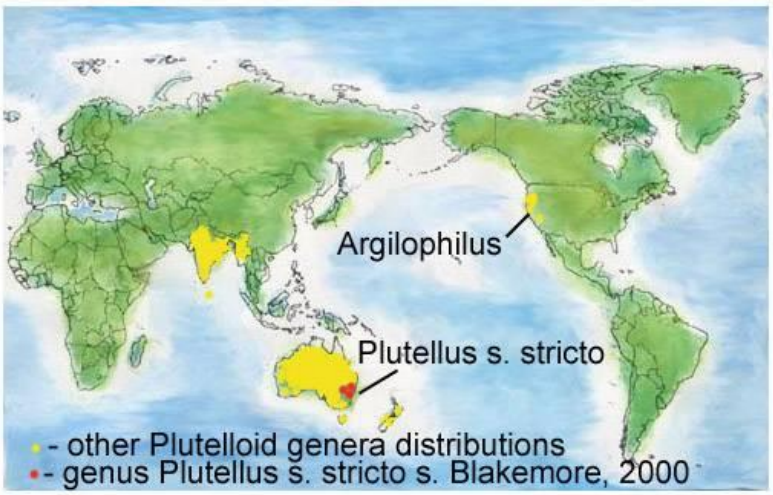
Ocnerodrilidae, with a natural pan-tropical distribution, and its probable descendent, the Acanthodrilidae, are both relatively primitive and their wide distributions perhaps represent Gondwanan or Pangean [or Pannotian, or maybe Rodinian (Torsvik, 2003)] origin. From Acanthodrilidae are progressively derived Octochaetidae (and/or Benhamiidae) and Exxidae with meronephry and non-tubular prostates, respectively. Octochaetidae as currently defined is debatably polyphyletic requiring restriction: e.g. as Octochaetidae s.s. for relevant genera such as Australian and NZ *Octochaetus* plus the Indian octochaetids, with tropical *Dichogaster* and related genera in Benhamiinae as revised by Csuzdi (1996) but elevated to family level.

[**Note**: It is possible, or rather probable, that members of the currently defined Octochaetidae have arisen independently in different regions, e.g. in New Zealand and/or India versus those from Central America/Africa; however, precursors are almost certainly acanthodril-like in all cases; thus 'Octochaetidae' could be more of a 'convenient' classification denoting a common development stage, irrespective or region/period. Perhaps a key to this is explaining why there are no native Acanthodrilidae in India while Octochaetidae flourish and are dominant there. Similar arguments may pertain to ocnerodril-like precursors to Acanthodrilidae, and so on…].

In southeastern North American, that palaeogeographers now believe was connected to Gondwana rather than Laurentia, *Diplocardia* and related taxa appear closely related to Australian/NZ *Diplotrema* but may actually belong in a separate group similar to Acanthodrilidae for which the name Diplocardiidae is available (as per Michaelsen, 1900).



Megascolecidae may also have arisen from the Acanthodrilidae or developed independently and it appears a mainly east Gondwanan taxon (e.g India/Australasia) although it has now spread thoughout Asia. It is also possible that its origins may also have been pre-Pangaean or even Rodinian which would partly explain occurrence of plutelloid megascolecid genera in North America (their nearest related general being in Australia and India) as due to fragmentation of Rodinia and subsequent formation of Pangea [or the Nearctic megascolecids in northwestern North America may belong in a relictual but separate group for which the name Argilophilinae is available, although this name may compete for priority with Vejdovsky's (1884) Pontodrilidae and Plutellidae].



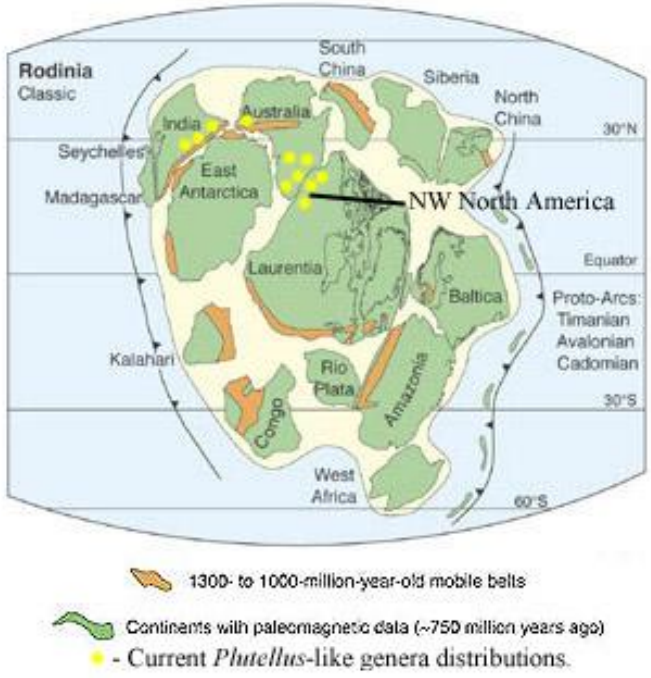


Fig. 1: A conventional reconstruction of Rodinia at 750 Ma (after Torsvik 2003).

[Fig. after Torsvik (2003). See also www.ucmp.berkeley.edu/geology/tecall1_4.mov].

Evidence for important pieces of the 'jigsaw puzzle' of earthworm biogeography are entirely missing for the fauna of Antarctica that was unfortunately obliterated by ice.

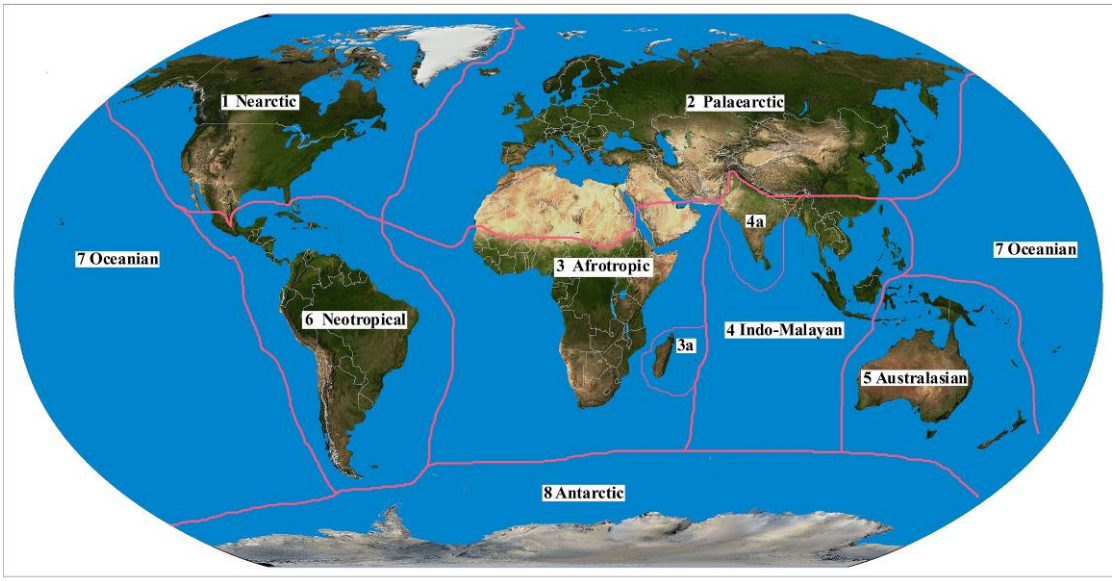
While simultaneously colonizing the Indo-Australian archipelago, proto-megascolecids on the Peninsular Indian fragment of Gondwanaland may have transported a speciating fauna that radiated to Asia after collision with the Laurasian plate; e.g., *Perionyx* is believed to have arisen in the Himalayas when passage to India or to Asia was possible as the mountain ranges were forming or by way of valleys such as the Rajmahal gap (Gates, 1972: 15).

Blakemore (2007 and *vide infra*) argued that *Pontodrilus* resembles the earliest 'primitive' precursors to the family Megascolecidae, similar to *Plutellus* with which it was variously combined in the past, and that determining the origin and nature of *Pontodrilus litoralis* may help explain the family provenance. Two family names may be available for these earlier forms, Pontodrilidae and/or Plutellidae, that would leave the residue of Megascolec-inae/-idae, defined by *Megascolex* s. stricto for similar, more derived, forms.

Easton (1979) postulated an origin of more advanced pheretimoid genera in the Australian plate (probably the New Guinean portion) followed by invasions westwards via the Indo-Australasian Archipelago. Conversely, an Oriental development for pheretimoids could be a derivation (meronephry and gizzard displacement to segment 8) from ancestral megascolecid stock having an evolutionary centre still further east, perhaps around the location of present-day Thailand (Gates, 1972). In either case, the Asian pheretimoids probably share common ancestry in Gondwanaland with the advanced Indian and Australian megascolecids such as *Megascolex*, *Lampito*, and *Anisochaeta*.

Recently human-mediated transportation of various allochthonous megascolecids has reunited these Oriental and Australasian faunas after many millions of years (Ma) of separation. The capacity for pheretimoids to opportunistically occupy new areas, especially where the soil is cultivated, is evidenced by distributions of their robust peregrine species in the tropics around the world matching that of the Lumbricidae in more temperate regions.

Earthworm Family Distributions relative to Ecozones or Bioregions – Summary



Ecozone (Bioregion): 1 Nearctic 2 Palaearctic (1+2 = Holarctic) 3 Afrotropic (Ethiopian) 3a Madagascan (Malagasy) 4 Indo-Malayan (Oriental) 4a Indian 5 Australasian 6 Neotropical 7 Oceanian 8 Antarctic

Megadrile Earthworm Families (after Blakemore, 2000, 2006, 2013, 2014): 1 Moniligastridae 2 Ocnerodrilidae (inc. Malabariinae) 3 Acanthodrilidae *sensu* Blakemore, 2000 (?inc. 3a Diplocardiinae, ?3b Maheinae 3c Wegeneriellinae) 4 Octochaetidae (inc. 4a Trigastrinae, 4b Benhaminae 4c Typhoeinae 4d Hoplochaetellinae) 5 Exxidae 6 Megascolecidae *sensu* Blakemore, 2000 (inc. ten subfamilies after Blakemore, 2013) 7 Kynotidae 8 Microchaetidae (inc. Kazimierzidae) 9 Tritogeniidae 10 Eudrilidae (inc. Pareudrilinae & Polytoreutinae) 11 Hippoperidae 12 Almidae 13 Criodrilidae (?inc. Biwadrilidae) 14 Hormogastridae (?inc. Ailoscoledicae) 15 Ailoscolecidae (?inc. Komarekionidae) 16 Sparganophilidae 17 Lutodrilidae 18 Lumbricidae 19 Glossoscolecidae 20 Tumakidae

1 Nearctic – 1*, 2*, 3*, 3a, 4*, 6, 6*, 10*, 13*, ?14*, 15, 16, 17, 18, 18*, 19*.

2 Palaearctic – 1, 2*, 3*, 4b*, 6 (Far East Asia), 6*, ?10*, 12 (in Egypt), 13, 14, 16*, 18, 18*, 19*.

3 Afrotropic – 1*, 2, 3, 3*, 3c, 4*, 4b, 6*, 8, 9, 10, 11, 12, 18*, 19*.

3a Madagascan – 2*, 3, 4 (*Howascolex*), 4b*, 6*, 7, 10*, 19*.

4 Indo-Malayan – 1, 2*, 4, 4b*, 6, 6*, 10*, 12, 18*, 19*.

4a India – 1, 2 (Malabariinae), 3*, ?3b, 4, 4b*, 4c, 4d, 6, 6*, 10*, 12, ?13*, ?16*, 18*, 19*.

5 Australasian – 1*, 2*, 3, 4, 4*, 4b*, 6, 6*, 10*, 18*, 19*.

6 Neotropical – 1*, 2, 3, 3a, 3c, 4, 4a, 4b, 5, 6*, 10*, 12, 13*, 16, 18*, 19, 20.

7 Oceanian – 1*, 2*, 3*, 4*, ?4b, 6, 6*, 10*, 18*, 19*.

8 Antarctic – 3, 6*, 18*.

*Present only by accidental/deliberate introduction; (note Acanthodrilidae absent from India & Asia).

Biographies of Esteemed Earthworm Taxonomists

Brief biographies of some early worm taxonomists are given in this section, mostly after Hans Hansson's BEMON website (Dec., 2008), alphabetically:-

Frank Evers **Beddard**, (1858-1925) F.R.S., Prosector to the Zoological Society of London and Lecturer on Biology at Guy's Hospital. "*Although he had not been an exceptional student, as a professional figure he was a hard worker and turned out several hundred publications*" on birds, annelids (mainly oligochaetes), and various invertebrate groups, also biogeography and animal colours. He was editor for the HMS '*Challenger*' Expedition. He laboriously described 222 earthworms (including 5 jointly with Sophie Fedarb), although many of his names were later synonymised. Unfortunately, much of his slack work still needs to be redone.

His publications and a brief gushing biography as "*the greatest authority in the universe*" (sic) are provided by Coles (1981: 300 Ref.) who also lists some original type repositories, not just for BMNH but also for some other institutions, viz..

Muséum National d'Histoire Naturelle, Paris.

Zoologisches Museum fur Naturkunde der Humboldt Universitat, Berlin.

Museo ed Instituto di Zoología Sistemática dell Universita di Torino.

Rijksmuseum van Natuurlijke Historie, Leiden.

National Museum of Natural History, Smithsonian Institution, Washington.

Naturhistorisches Museum, Wien.

Zoologisches Institut und Zoologisches Museum, Hamburg.

Other workers, myself included, question the reliablility of much of his work (Blakemore, 2014). Some of his publications are here: http://www.biodiversitylibrary.org/creator/57604/author#/sections. A note he sent to Perrier is preserved in the pages of a book here – Ref.

Sir William Blaxland **Benham**, (1860-1950), U.K. (University College), New Zealand and Tasmania annelidologist (mainly specialized on oligochaetes, but he worked also on polychaetes), Professor of Biology in Otago in 1898. He named ca. 89 taxa and often had a lucid and clear vision of correct phylogeny and taxonomy. His work is very thoughtful and provides a stable and reliable platform to work from. In 2000, Dr Ken Lee kindly passed down to me Benham's copy of Michaelsen (1900).

[Obituary here: http://rsnz.natlib.govt.nz/volume/rsnz_80/rsnz_80_01_002280.pdf and here].

Augustin Pyramus **de Candolle**, (4 Feb.) 1778-1841 (9 Sep.), from Geneva (who coined the term "*taxonomy*"), edited "*Flore française*" for Lamarck.

Lev Vladimirovich **Cernosvitov**, 1902-1945, of Russian/Ukranian extraction but adopted by newly formed Czechoslovakia after retreating with the White Army to the Black Sea and exile in Constantinople while still in his teens. Taking up oligochaete research, he tragically died of a heart attack 4 days after finally obtaining a job at the Natural History Museum London.

The Hero of modern biology and founder of soil ecology, Charles Robert **Darwin**, (born 12 Feb., 1809 – Shrewsbury - died 19 Apr., 1882 – Down), British naturalist, cirriped (barnacle) monographer, with an interest in earthworm studies for more than 40 years – i.e., from 1837 when he read a paper before the *Geological Society of London*, in November 1, to 1881 when his "*Vegetable Mould* (= humus) *and Worms*" book was first published. It is reported that he thought his earthworm work was his most important contribution. Egerton (2011) further argues that Darwin was also the *de facto* instigator of the broad and modern science of Ecology:

> "*In 1866, Darwin's German disciple, Ernst Haeckel, sent him a copy of his* Generelle Morphologie der Organismen *(two volumes), which named and defined a new science of "oecologie." Darwin's copy has passages marked or annotated, though not the ecology discussion (Di Gregorio and Gill 1990:355–357). Yet, Darwin's own writings are full of ecological observations and comments. His* Journal of Researches *(1839) and other Beagle writings were important beginnings (Egerton 2010b); the climax of his ecological contribution was in the* Origin*, with modest contributions in other works discussed above. Linnaeus had first invented an ecological science in 1749, the economy of nature (Egerton 2007b:81–82), but since he believed species were unchanging, so was his economy of nature. In the first half of the 1800s, naturalists developed a changing economy of nature concept (Egerton 2010a), without it becoming the basis of an important science. Something more was needed before that happened, and Darwin's evolutionary ecology became a foundation on which ecological sciences would be built two decades after his death*."

Kiwi born Joseph James **Fletcher** (1850-1926) director of the Linnean Society of New South Wales 1893-1919, also taught science at Newington College, Sydney.

Dr Gordon Enoch **Gates** (11 January, 1897-11 June, 1987), Oligochaetologist. An American schoolmaster in Burma in the 1930's, a prolific taxonomist (ca. 369 names, a few of them good) whose original publications spanned nearly 60 years (e.g. Gates, 1925 - Gates, 1982) – see publication lists of G.E. Gates, [here 12 April, 2004] and at Harvard MCZ. Gates liked to write lengthy descriptions, but he rarely included any figures so we must struggle to comprehend what he is talking about, and because he constantly changed his mind, at any particular time. A (rare) instance of his loquacity linked to an image, is here: Gates (1929, fig. 2) of *Drawida constrica* whereas some other Drawidas were described with quite irrelevant and unhelpful figures of just a part of just one spermatheca from a specimen. A clear case of not helping us to see the forest by blocking it with a splinter from a tree! Although he provided insight and an understanding to parthenogenetic morphs, his family level classification was also persistently off-track in denying the 'Classical System', this in itself not so bad for opening dialogue, but it allowed some regionalists who came after to think that they too could have a different opinon to those formed through hard work over many years by Michaelsen and Stephenson. Respect for his work was considerably reduced when he continued to use the genus name *Pheretima* for 10 years after Sims & Easton (1972) had cogently showed how it was superceded. He also has a bizarre and inconsistent method of citing species as being synonyms when they were mere citations of a name that he happens to disagree with, i.e., the species may yet be good, but you will need to repeat the process from original sources and prove or disprove this for yourself. Yeah, thanks G.E. for wasting our time to make your pointless point. No one person 'owns' taxonomy – it is for the benefit of all and we must all follow the code and ethics of ICZN, or we make our own rules and must accept being shot down with them to 'crash and burn'.

Almost in complete contrast, an often under-rated and even reviled Scientist who had the misfortune to be ahead of his time and thus incomprehensible to the lumpen 'pack', Jean Baptiste Pierre Antoine de Monet **de Lamarck** (or sometimes de Drouet), or just called Chevalier de Lamarck, (1 Aug.) 1744-1828 (18 Dec.). He was the 11th (last) child of a poor count from Picardie (Bazentin-le-Petit) [hence the title

Chevalier (= knight) for a poor nobility person] and he first coined the terms 'Biology', 'Invertebrates', and 'Annelida'; he separated arachnids and crustaceans into different classes from insects. Born in the town of Bezartin or Bazentin in the Somme (that was destroyed in the 1914-18 war), he was a soldier from age 17 to when he was injured in the neck by a fellow soldier in 1766, and he returned to his medical studies, and after this a scholar and musician. He worked at Muséum National d´Histoire Naturelle in Jardin des Plantes (so renamed in 1790 by Lamarck from Jardin du Roi during the revolution). His first wife died, but he later married a woman 30 years his junior, when she died he remarried a third and possibly a forth time. He fathered to 8 children. In his dotage he was a blind pauper, cared for by his devoted daughter Cornélie. On dying, this heroic son of France, to the shame of that country, was buried in a temporary lime-pit, his work besmerched by Baron Cuvier (Ref.).

Dr Kenneth (Ken) Earnest **Lee** (7th May 1927, Wanganui, New Zealand – 14th January 2007, Adelaide, S.A.), highly respected scientist, earthworm ecologist and taxonomist. In 1948 he finished his MSc at Victoria University, Welington under Prof. Sir W. Benham, and in 1959 he completed his monograph on the "*Earthworm fauna of New Zealand*", before moving to Adelaide and extending his studies to include termites and the faunas of the Pacific and Southern Ocean. His text "*Earthworms: their ecology and relationships with soils and land use*" (Lee, 1985) remains the definitive work, successor to Charles Darwin's 1881 ecological book. Ken was internationally acknowledged for his work in soil zoology and soil science. [Source: Yeates, G. & Churchman, J. (2007) Obituary: Ken Lee (1927–2007)]. He described 97 taxa.

Herr Prof. Johann Wilhelm **Michaelsen**, (9 Oct. - Hamburg) 1860-1937 (18 Feb. - Hamburg), was an renowned annelidologist who mainly specialized on oligochaetes of which he named named 1,083 species, but he worked also on polychaetes. Curator of the invertebrate department of the Zoological Institute und Zoological Museum between 1887-1923. He was leader of the German South-West Australian expedition. Michaelsen's >200 scientific papers are listed here and he must be recognized as the father of earthworm taxonomy. A great worker whose obituary, from *Nature* 140, 308-309 (21 August 1937) | doi:10.1038/140308a0, is here: *"PROF. J. WILHELM MICHAELSEN, Hauptkuatos in the Hamburg Zoological Museum, died*

on February 18 in his seventy-seventh year. Born in Hamburg, he joined the Hamburg Museum in 1887 and worked there until the time of his death."

Pontoscolex corethrurus author was **Johann Friedrich Theodor Müller** (1821-1897), always known as *Fritz*, a German biologist and physician who emigrated to southern Brazil, where he lived in the German community of Blumenau on Santa Catarina Isl. There he studied the Atlantic forest south of Sao Paulo, and was an early advocate of Darwinism. Müllerian mimicry is named after him.

Edmond Perrier (1844-1921) French invertebrate zoologist and taxonomist, and Lamarckian evolutionist. Professor-administrator at the Musée d'Histoire Naturelle in Paris, 1876–1900.

Constantine Samuel **Rafinesque-Schmaltz**, (Turkey, 1783-1840, Philadelphia) was born in Turkey by a French father and a German mother. He immigrated to USA in 1802 to settle among the New Harmonists, but soon changed his mind. About the "*gullible genius*" Rafinesque it has been said "*No more remarkable figure has appeared in the annals of science*". He was a Jack-of-all-trades, a very great traveller and polyglot, who from time to time partly lived in Italy (mainly Sicily e.g. Palermo 1805-15). During the Italian-French war, he found it wise to add his mother's name to his father's surname. Succesively he also grew excentric, with a taste for everything which was new and untested and became somewhat corpulent, but his taste concerned not only food: one small example is that many of all the taxon names that he proposed are altogether fictive and not possible to derive etymologically, but they evidenty tasted delicious on his tongue. Eventually he may have passed the insanity border and was considered a bit crazy. He once had a love affair with a Sicilian girl, but she left him when he lost his fortune. His young son - named Charles Linnaeus - had died in infancy, while his daughter Johanna became a stage singer and estranged from her father.

Marie Jules César Lelorgne **de Savigny**, an account, under 'de Lamarck' has this section on **de Savigny**:- "*The annelid work by the Frenchman Marie Jules César Lelorgne **de Savigny**, (5 Apr.) 1777-1851 (5 Oct.), in "Description de l'Égypte ...", which is dated 1809, is namely considered to be published in 1822 by ICZN (Op. 1461). Savigny, who, - like Geoffroy Saint-Hilaire (q.v.) - attended Napoleon on his Egypt expedition, wrote about the fauna in the Mediterranean Sea and the Red Sea and discovered that mouth parts of arthropods were transformed extremities. He was born in Provins, dépt. Seine et Marne, E of Paris, went to Paris at age 16, finishing*

his studies there, but being very interested in botany, he simultaniosly worked at the Muséum National d'Histoire naturelle, and Cuvier suggested to Napoleon that the 21 year old Savigny should follow him as zoologist to Egypt. Savigny became responsible for the invertebrates, ... However, in 1824 his affliction returned in a worse form and he became more or less blind, having terrible optical hallucinations and he moved to "chalet de Gally" in the Versailles Park, owned by his friend M. Alexandre Letellier de Sainteville, and stayed there for the rest of his life."

Dr. Ludwig Karl **Schmarda**, (23 Aug. - Olmütz (today in Czech Rep.)) 1819-1908 (7 Apr. – Wien, Austria), (PhD in Olmütz in 1841) published in 1861 a work dealing with animals collected during a private circumnavigation in 1853-57. Schmarda had 'hitch-hiked' around the world with different sailing vessels. Between South Africa and Australia he experienced very bad weather, seasickness and a mixture of diseases (e.g. scurvy). In Chile, all his collections made to that point was destroyed in a fire and in Panama he was robbed, but despite these drawbacks, he kept publishing the results of his collections from this long trip (Schmarda, 1861).

Prof. Sir Walter Baldwin **Spencer**, (1860-1929 died on Navarino Island, Tierra del Fuego), zoologist anthropologist and art patron who lived in Melbourne.

Dr John **Stephenson**, (1871-1933), physician and army officer, who published many papers on (mainly Indian) oligochaetes starting from around 1915. He was a Doyen of earthworm study, he also translated Arabic zoological literature into English.

Dr Alfred Lothar **Wegener**, (1 Nov. - Berlin) 1880-1930 (? Nov. - Greenland), geologist / meterologist, well-known for his hypothesis first published in 1915 of continental drift (from an original Pangaea). He froze to death together with his Inuit companion, Rasmuns Villumsen, when heading a rescue mission over the ice cap of Greenland [see http://www.ucmp.berkeley.edu/history/wegener.html], he died well before his theories of Continental Drift rose above ridicule to be generally accepted. It is surmised that he shared his ideas with Dr W. Michaelsen, indeed Michaelsen was one of the first proponents of Continental Drift, producing papers as early as 1922 that used earthworms, particularly at the family level in his insightful classification, to support the theory and to explain the world distributions of the earthworm taxa.

-oOo-

6. GUIDE TO THE SPECIES

Methods of systematics study

Details of the taxonomic characters required for classification of species as presented under ECO-TAXONOMY above are also available from sources such as Benham (1890 although now somewhat dated); Beddard (1895); Michaelsen (1900); Stephenson (1930), Lee (1959a, 1959), Ljungström (1970), Sims & Gerard (1985, 1999) and Csuzdi & Zicsi (2003) for lumbricids, and Sims & Easton (1972) and Easton (1979) for pheretimoids. However, one of the benefits of using the methods and systematics derived by the current author is that the often futile search for negative or absent characters, a prerequisite for some older, and now largely discredited schemes, is avoided (Sims & Gerard, 1985; 1999: 40; Easton, 1979: 20; Blakemore, 2000; 2007, 2013). Imagin if we had to continue to search in vain with high powered magnification in the terminal segments of specimens for minute **or *absent*** preseptal nephridial funnels in order just to class them before we could start proper identification. Quite ridicuolous and unworkable.

Peregrine lumbricids (family Lumbricidae) can be partially identified by their external features, but in other families some dissection must be attempted in order to determine the species. A consequence of the tendancy of several peregrine species to parthenogenesis is that the sexual organs, of primary importance in earthworm taxonomy, become atrophied or degraded. In these cases, the somatic characters (e.g. setae, and nepridial and digestive systems) may still prove sufficient for identification; as indeed may some behavioural traits and molecular (DNA) characteristics.

Most specimens located in the current studies were inspected under low-powered magnification, sketched in the author's usual style using a *camera lucida* attachment, dissected by longitudinal incision dorsally while pinned on a wax tray while immersed in ethanol (or water) to prevent desiccation. For most lumbricine species, the setal ratios (of disputed taxonomic value) on one side of segment 12 can be calculated from their inclusion in the figures with their exact spacing, but the value of this data is questionable. When present, the clitellum is shaded, and other structures of taxonomic significance are shown *in situ*. All scale bars are 1 mm unless otherwise stated.

Thus the presentation format of species descriptions and illustrations have been devised to facilitate rapid confirmation of identity and easy cross-reference as a service and courtesy to the investigator. Some considerations for inclusion in descriptions are:

• major synonymies, especially those involving nomenclatural changes, are listed (reference to fuller listing is also made);

• 'distributions' for taxa are derived from sources cited;

• 'localities' are those of material collected and examined in the current study;

• 'habitats' are intended (along with the morphology and gut contents) to give some indication of ecological strategy and species associations, as well as to assist fieldworkers locate further material in their locality.

• biometry is based on varying numbers of inspected specimens, and is presented as range values or, where only one or two specimens were found, the actual dimensions.

• calculated setal ratios, although of debatable taxonomic use, are usually presented as means (specimens permitting) relative to intersetal distance **ab** expressed as unity, or as %'s of circumference; alternatively, a sample of actual intersetal distances is sketched on a figured specimen, as herein, for researchers to calculate by their own preferred method.

Keys are provided to conduct the reader through various levels to the species. General comments accompany species descriptions. While most generic definitions are derived some are amended following recent revisions and descriptions of new species. Definitions at family level are given where there are known peregrine members. Conventions, abbreviations and technical and anatomical terms (with notes on their importance to systematics) are given in a Glossary of definitions in an Appendix.

As commented on above, guides to species names (but not yet to most descriptions) are available online from time to time, e.g. the TRITON or ION index to organism names maintained by **BIOSIS** in the UK … useful for checking species names and some higher classifications, see http://www.organismnames.com/.

It is perhaps opportune to note here that many earlier species descriptions were rather brief or sketchy and often contained errors introduced initially or in transliterations. For example, F. E. Beddard (biographied above) published copiously and profusely on annelid systematics and, although wordy, his descriptions and figures were often unreliable and needed (and still need) confirmation. Thus Stephenson (1932) re-examined British Museum specimens from the Skeat Expedition originally described by Beddard (1900) and was forced to make many corrections that Stephenson said "*place our knowledge of Malay Oligochaeta on a firmer foundatio*n". Whereas Gates (1942,

1943) – himself far from an innocent bystander, e.g. his placing various authors' species concepts in his revolving synonymies almost randomly with or without saying whether the original authority's concept was included – was frustrated to the use of exclamations marks with inconsistencies in Beddard's publications! Gates' did little to help us with his wordy descriptions unhindered by any helpful diagrams, not even sketches. He also loses my respect when for 10 years, from 1972-1982, he deliberately ignores the realization of the *Amynthas* resolution for *Pheretima* by Sims & Easton (1972). There are many other contemporary examples, some even threatening to sue if anyone dares to legitimately criticize their mistakes and errors.

The result is that earlier publication have often mistaken names and/or descriptions and a taxonomist's job now, as always, is to repair and correct errors as soon as they are found and regardless of whether in the own author's or other authors' work and, most importantly, regardless of whether the other authors are yet alive or already dead. This is important as some taxonomists, and I have heard this stated publicly, think that it is somehow 'wrong' to correct errors of a living taxononomist. This is completely ridiculous and of itself wrong as Science can only progress by continual self-inspection and improvement. Any cynical protection only does a disservice for all, but especially for students entering Science for the first time.

To admit one's mistakes is the measure of a great man and of a 'good Scientist' (and here I would really like just say a 'normal scientist' as this should be expected but, unfortunately as is all too common, a scientist who avoids the facts is not a true Scientist).

[**Note:** Burrowing, segmented, 'worm-like' animal that yet have tiny eyes and a reptilian mouth are earthworm-predatory caecilians (Amphibia: Gymnophiona: Caeciliidae) widely distributed in tropical areas of Asia (e.g. southern China, southern Philippines, Southeast Asia, Sri Lanka, and India), the Seychelles, also in Africa, Central and South America where they are called "*tapalcúa*" and grow up to 2m in length (see www.gymnophiona.org or en.**wikipedia**.org/wiki/Caecilian Jan. 2006)].

Aquatic, mainly microdrile species, are provided with their own guides, e.g. by Brinkhurst (1971), Pinder & Brinkhurst (1994), or Kathman & Brinkhurst (1998). For true 'earth-worms', that occur in water or arboreally (in trees) or caves as well as in the soil, Stephenson (1930: 719) considered it "*unnecessary from the point of view of convenience*" to consider grades between Order and Family, so he "*dispensed with groups above the level of family in his great monograph*" (Sims, 1980: 104). I concur.

Higher Taxonomic Groups [General/Theoretical entities are ungoverned by ICZN] [Domain/Empire/Regio Eukarya; Kingdom Animalia; Sub-kingdom Metazoa (multicelled, heterotrophic, eukaryotic animals) or Eumetazoa (cells form tissues); Bilateria (bilaterally symmetric, and triploblastic - with three types of embryonic germ cells); Protostomia (one-way digestive tract plus a coelom, i.e., "Coelomates"), ?Lophotrochozoa and/or "Lophozoa" and/or "Protocoelomates" and/or "Annelidamorpha", etc., etc.].

Phylum ANNELIDA Lamarck, 1802 (segmented worms)

Subphylum/superclass CLITELLATA (annelids with a collar-like clitellum)

Class OLIGOCHAETA (worms with few/small setae, cf. numerous setae on parapodia of marine Polychaeta, and cf. carnivorous Hirudinea leeches)

(Super-)Order HAPLOTAXIDA (variously divided into mainly small, aquatic **microdriles** {or Order Microdrilacea} including Enchytraidae and Haplotaxidae; and mostly larger, terrestrial and limnic/littoral **megadriles** {or Order MEGADRILACEA}). [Orders ***Microdrili*** (*Lumbricomorpha minora*) (clitellum extending 1-2 segments) and ***Megadrili*** (*Lumbricomorpha majora*) (clitellum >2 segments, meroic or holonephridial blood capillaries present)]*.

Suborder MONILIGASTRIDA (Clitellum one cell thick, eggs large, yolky)

Suborder LUMBRICINA De Blainville, 1828 (Clitellum thick, eggs small)

Families – ca. 20 of – these are introduced in the Keys that follow.

*Microdrili and Megadrili Benham (1890: 218) defined in the Glossary.

Introductory Key to the FAMILIES of Earthworms [After Michaelsen (1900, 1907), Stephenson (1930), Omodeo (1963), Gates (1942, 1972), Sims (1980), Easton (1981), Csuzdi (1996, 2000), Blakemore (2000, 2007, 2013, 2014), etc.].

Occasional species may have suppressed anteriors with segments 1 and 2 fused or aborted – this determined by setae on 'first' segment, by internal septa, and by reproductive organs in other than the usual locations (viz., testes in 10 & 11, ovaries in 13). Rarely, supernumerary segments occur, e.g. due to mutation or regeneration of specimens. In such cases, add (or subtract) counts to the segment numbers in the keys below. A single pair of obvious, large holonephridia per segment are classed as '**holoic**' and all other combinations are emcompassed as '**meroic**' (i.e., **non-holoic**) which, for practical purposes, the novice need not bother discriminate into micro-meronephridia, mega-meronephridia, or what-have-you.

1. Clitellum usually formed from a single layer of cells in the region of the male pores; male pores on or before 13 (usually in segment immediately behind testis and before female pores); macrolecithal, i.e., eggs large, yolky 2
[Suborder Moniligastrida in Order (or Class?) Megadrili]

Clitellum more than one cell thick; male pores after 12 (one or more segments behind testis and typically behind female pores); microlecithal (eggs smaller) 4
(Suborder Lumbricina also included in Megadrili = the megadrile earthworms).

2. Male pores on 13 (with separate prostatic pores in 11, 12 and 13 in *Syngenodrilus*), or with male pores in atria on 10 or in 10/11 (or 11/12 and 12/13) and prostate-like glands associated with the terminal portions of the sperm ducts 3

Male pores two pairs on 12, or on 11 and 12; (spermathecae one to three pairs in 6/7-8/9) ... **Haplotaxidae** [Classed with the microdriles but similar to probable precursor of megadriles; cosmopolitan distribution; aquatic or limicolous, typically predatory. *Haplotaxis gordioides* (Hartman, 1821) (fig.), 400 mm long by 2 mm, widely distributed (e.g. Eurasia and U.S.A.) possibly transported; abundant in European WWI trenches (Gates, 1972: 59; 1982: 18)].

Male pores one pair on 12; clitellum on 12 and adjacent segments (spermathecae opening near 4/5, or 3/4 and 4/5) ..... **Enchytraeidae** (Small white segmented 'pot worms'; usually excluded from megadriles and considered

with microdriles; littoral, aquatic or terrestrial and mostly in moist forest soils; cosmopolitan distribution but uncommon in tropics).

3. Male pores paired on 13, female pores 14 (clitellum 11,13-16); gizzard absent (*Alluroides*) or doubled in 8-9 (*Syngenodrilus*), holoic nephridia absent from some anterior segments; spermathecae in 8, testis in 10, ovaries 12 (Michaelsen, 1900: 106 (laps.?)) or 13 (Gates, 1972: 48), (prostates diffuse) .... **Alluroididae** and/or **Syngenodrilidae**. Argentina/Africa (aquatic microdriles).

Male pores on 10 or in 10/11 with testes and male funnels in intraseptal testis sacs; (male pores rarely two pairs in 11/12 and 12/13); female pores just behind 11/12 (or 12/13 or 13/14); moniliform gizzards present …. **Moniligastridae** [Indo-Oriental regions; Suborder Moniligastrida included in terrestrial megadriles].

4 (1). Prostatic glands, or 'prostate-like' bursae, discharging through or near male pores or on adjacent segments (glands aborted in abnormal specimens) …... 5

Prostatic glands absent; any bursae, if present, not associated with male pores 12

PROSTATES PRESENT

5 (4). Male pores posterior to segment 16 ……..... 6

Male pores on segments 13 (rarely), 15 or 16 .....……... 11

6. Last hearts in 11; prostates tubular, Ca glands or 'diverticula' typically in 9 or 9-10, or intramural spaces in some of 8-10 (Ocnerodrilinae), or absent (Malabariinae) .....……. **Ocnerodrilidae** [Circumtropical but not Oriental/Australasian regions; found in Neotropics, Africa; India; about 21 genera, a few species transported; often aquatic].

Last hearts posterior to segment 11; (Ca glands, if present, not in 9 or 9-10) 7

7. Male pores open separately on 18 from paired prostate pores in 17 and/or 19, or male and prostatic pores combined or separate on 17 or 19 .....… 8

Male pores on 18 (or homeotic equivalent) combined with pores of a single pair of prostates, or on 17 and emerging from ducts of 'euprostates' ……. 10

8. Holoic; (with prostates tubular), gizzard single or reduced ….. **Acanthodrilidae**

[(Gondwanan or Pangaean?) currently occurs in Australasia, (northern Madagascar?), South Africa, and Patagonia in South America; cf. Diplocardinae]

Holoic; (prostates always tubular?), gizzards multiple ….. **Diplocard-inae/-idea** ** (now present in southern USA/Mexico, origin Gondwanan or Laurasian?)

Meroic; (with prostates tubular or non-tubular) …….....…….. 9

9. Prostates tubular .... **Octochaetidae** [Indo-Australasian, Oriental, Ethiopian, Neotropical if Benhamiinae is included; otherwise occurring in Australasia, India, (southern Madagascar and Mexico?)]

9a. Ca glands 2-3 extramural pairs after reproductive organs, commencing in or near segment 14; (often multiple gizzards) .... **Benhamiinae** Michaelsen, 1895/7 (?Ethiopian, Neotropical)

9b. Ca glands, if present, not as above; (gizzard usually single) .. **Octochaetinae** Michaelsen, 1900 (?Australasian, Indian, Oriental)

Prostates non-tubular (i.e., racemose or tubuloracemose) ..... **Exxidae** [Neotropical: Central America and Caribbean, no longer considered 'Australasian'; 9 known species in 2 (or 3?) genera (see Blakemore, 2000)].

10 (7). Male pores on 18, spermathecae in pre-testicular segments; (prostates tubular to racemose, nephridia holoic or meroic, setae lumbricine to perichaetine), gizzard(s) reduced, single or multiple ……. **Megascolecidae** (Pangaean?); (see sub-family refinement in Appendix – here)

Male pores on 17, spermathecae absent from pre-testicular segments but as coelomic cavities combining with ovaries; ('euprostates' present, holoic, lumbricine), gizzard(s) reduced, single or multiple …… **Eudrilidae** (Tropical Africa south of the Sahara; about 45 genera, one species introduced to other tropical areas).

11 (5). Body quadrangular; male pores on porophores, gizzard(s) absent .....… **Criodrilidae** [Southwestern Palaearctic: Europe, Middle East, Russia and Siberia to Pacific coast and Japan (aquatic *Criodrilus* with only 3 or so spp. has male pores on 13 or 15 and is introduced into UK and USA)].

Body cylindrical; male claspers in copulatory pouches on 15, gizzard in 5 ..… **Kynotidae** [Malagasian: Madagascar; 12 species in primary forests (*Kynotus*)].

PROSTATES ABSENT

12 (4). Oesophageal gizzard(s) or dilations in pre-testicular segments …… 13

Oesophageal gizzards or dilations absent from pre-testicular segments ……. 17

13. Extra-mural calciferous glands present …….. 14

Extra-mural calciferous glands absent (may be intramural) ……. 15

14. Gizzard in 6; (supra-oesophageal vessel present) ……..…… **Glossoscolecidae** [Neotropical: Central, S. America, Caribbean; 200 species, a few species distributed and circumtropical in forest soils or near coast].

Gizzard in 7; (supra-oesophageal vessel absent) ….. **Microchaetidae (inc. Kazimierzidae)/ Tritogeniidae** [Terrestrial, Africa especially S. African grasslands (e.g. *Kazimierzus, Microchaetus, Tritogenia*), (cf. *Kynotus* with gizzard in 5). Monotypic *Branchydrilus* Benham, 1888 for *Br. benhami* Michaelsen, 1900: 463 has unknown homeland].

15 (13). Body quadrangular in section, at least in hind-body; (supra-oesophageal vessel present) ……..……..…… **Almidae** [Tropical equatorial (South America, Africa, Indo-Asia); 6 genera, 40 species, some possibly peregrine; aquatic in tropical East Africa (*Callidrilus*), India and Southeast Asia (e.g. *Glyphidrilus*). Also limnic, amphibious, or limicolous or in caves in South and Central America, India]. [Note: South African *Tritogenia* Kinberg, 1867 is meroic not holoic and is now placed in Microchaetidae/ Tritogeniidae, but some earlier authors, as for *Glyphidrilus*, had it in Almidae].

Body cylindrical; (supra-oesophageal vessel absent) …… 16

16. Male pores paired on 15; (two or three oesophageal gizzards each restricted to a single segment in 6-8) ……..… **Hormogastridae** [Mediterranean, 28 taxa in 4 genera; one species, *Hormogaster redii* Rosa, 1887 in Africa (Tunis and Algeria) and a single record of transport to North America (Gates, 1954: 248; 1972: 61)].

Male pores paired on 22; (one or two oesophageal gizzards each occupying two segments) …….. **Ailoscolecidae/ Komarekionidae** [Pyrenees and southeast USA, two monotypic genera, viz. *Ailoscolex*

lacteospumosus Bouché, 1969 and *Komarekiona eatoni* Gates, 1974]. [Note: Sims, (1980: 108) put American Komarekionidae Gates, 1974 in synonymy (cf. Reynolds & Cook, (1993), Gates (1982: 26) but molecular studies now suggest *Ailoscolex* belongs in Hormogatridae so Gates' family may be restored].

17 (12). Testes two pairs in 10 and 11; (intestinal gizzards, when present, in some or all of 17-25) ……... 18

Testes ten pairs in segments 12-21; (intestinal dilations in 21-24) …. **Lutodrilidae** (Louisiana southeast USA; riverine or limicolous; monotypic).

18. Intestinal gizzards (and calciferous glands) absent ……. **Sparganophilidae** (Nearctic, Neotropical: North and Central America, introduced into Europe; Single genus accommodating a dozen or more species; limnic or aquatic).

Intestinal gizzards (and calciferous glands) present 19

19. Intestinal gizzards in or before 20; (calciferous glands present, male pores usually on 15 but some parthenogenic morphs of *Eiseniella tetraedra* have male pores displaced by several segment, most usually on 13 or 11) …… **Lumbricidae** [Holarctic: North America, Europe, Middle East, Central Asia to Japan; several species widely distributed; mostly terrestrial].

Intestinal gizzard in 25 (Ca glands in 20, dorsal pores present) ... **Tumakidae** [Monotypic for *Tumak hammeni* Righi, 1995 from Venadillo (Tolima) Columbia, South America].

**Michaelsen (1900: 121) disassociated his Megascolecidae subfamilies Acanthodrilinae (on pg 122) and Diplocardiinae (on pg 324) using a key like this:

1. Calciferous gland(s) or oesophageal pouche(s) in 9 .....…. Ocnerodrilinae
   Calciferous glands or oesophageal pouches absent or not in 9 …….. 2
2. (Acanthodriline male pores and) two or three gizzards in front of testis ……. 3
   Not such an arrangement of (male pores and) gizzards ....…....…… 4
3. Holoic ….....…… Diplocardiinae
   Meroic ……..……. Trigastrinae (?= Benhamiinae)
4. Vasa deferentia combined with prostatic pores (exit on 18) ….. Megascolecinae
   Vasa deferentia not so (usually exit separately) ……..…….. 6
5. Holoic ……..……... Acanthodrilinae
   Meroic ….....……..……. Octochaetinae

Michaelsen's divisions seem insightful and phylogenetically valid, but merit elevation to family level plus addition of Exxidae - a derivation of Trigastrinae (= Benhamiinae).

Approximate species (and genera) totals for the Families

[Data extrapolated from Dr Cs. Csuzdi's database (Aug. 2011, online from December 2003), from Blakemore (2008, 2010), Sims (1980) and the Family concepts in key above; cf. **Total Oligochaeta** above and data in Dr Anna Moreno's website, Dec. 2005 www.ucm.es/info/tropico/investigacion/grupodetaxonomia/catalogos.htm].

1 Acanthodrilidae – 732 spp (perhaps 20 genera)
2 Ailoscolecidae (including Komarekionidae) – 12 spp (2 genera)
2 Almidae – ca. 40 spp (maybe 6 genera) including the glyphidriles
3 Alluroididae – 12 spp in 6 genera from S. Africa and S. America including monotypic *Syngenodrilus* sometimes treated with microdriles or as separate family
4 Criodrilidae (including Biwadrilidae) – 11 spp (most now transferred to Almidae)
5 Eudrilidae – 357 spp (Pareudrilinae ca. 15 genera + Eudrilinae 30 genera)
6 Exxidae – 9 spp (2 or 3 genera)
7 Glossoscolecidae – 550 spp (probably 30+ genera)
8 [Haplotaxidae – 52 spp – a microdrile family]
9 Hormogastridae (Hormogastrinae, 23 spp + Vignysinae, 3 spp) = 26 spp
10 Kynotidae – 15 spp (1 genus)
11 Lumbricidae – 1,130 spp names (Lumbricinae ca. 30 genera + Diprodrilinae)
12 Lutodrilidae – 1 sp for *Lutodrilus multivesticulatus* McMahan, 1976 [Louisiana]
13 Megascolecidae – ca. 2,061 spp names (maybe 60 genera)
14 Microchaetidae – 153 spp (maybe 5 or more genera)
15 Moniligastridae – 185 spp (maybe 5 or more genera)
16 Ocnerodrilidae – 180 spp (Ocnerodrilinae ca. 18 genera + Malabariinae 3 genera)
17 Octochaetidae (Octochaetinae, 250 + Benhamiinae, 335 spp) = 585 spp (~30 genera)
18 Sparganophilidae – 14 spp
19 [Tiguassidae – 1 sp – a microdrile family, for *Tiguassu reginae* Righi *et al.*, 1978]
20 Tumakidae – 1 sp for *Tumak hammeni* Righi 1995 from S. America.

TOTAL nominal taxa = ~5,800 spp. as listed on Cs. Csuzdi's database (June, 2011) excluding ~53 microdriles in square braces above with some duplicates. Additionally ~1,200 more recent or obscure spp names, plus 3,600-4,000 microdriles may be added, thus a reasonable estimate of **Total Oligochaeta** is ca. 10,600-11,000 named spp. And, while the component of synonyms is unknown, many new taxa are anticipated from further eco-taxonomic survey (plus current fashion trend for claiming "*cryptic species*").

Family **Enchytraeidae** Vejdovsky, 1879

Type-genus and type-species: *Enchytraeus albidus* Henle, 1837.

Diagnosis (from Michaelsen, 1900; Stephenson, 1930, Gates, 1972; Dindal, 1990): Smaller worms mostly terrestrial in moist soils, others in aquatic or marine habitats. Setae in four bundles of 2 or 3-12 setae. Dorsal and ventral setae usually the same. Anterior (head-) pores present or lacking (dorsal pores present in *Fridericia*). Nephropores median to ventral setal bundles. Clitellum one-cell thick on 12 and spreading into adjacent segments when developed. Male pores one pair on 12. Female pores paired in 12/13 or 13. Spermathecal pores usually one pair in 4/5, seldom two pairs in 3/4/5. Oesophageal and intestinal gizzards, calciferous glands, and caeca absent. Pharyngeal glands in 4/5. Nephridia holoic. Ovaries on 11/12. Ova large yolky. Testes on 10/11. Penial bulb may be present but not atria nor prostates. Spermathecae simple or diverticulate often connected to digestive tract. Blood colourless or yellow.

Distribution: Holarctic, Siberia, Nova Zembla, Solovetski Is., North America, Greenland, Svalbad/Spitzbergen, all of Europe, Egypt, India, Southeast Asia, Japan/Korea, South America (e.g. South Patagonia to Tierra del Fuego), S. Africa, sub-Antarctic islands, Australia, Tasmania, New Zealand. Australian records are WA (Jackson, 1931; Springett, 1971); Qld e.g. Qld Uni. and Gatton College (Stephenson, 1933; and pers. obs.), NSW eg. Blue Mtns. (Michaelsen, 1907, and pers. obs.), SA (Handreck & Lee, 1981) and Tasmania (pers. obs.). The type-species, *Enchytraeus albidus*, is classed as euryhaline and is met with all over the globe (e.g. Benham, 1905; Jackson, 1931). Most records of enchytraeids in Australia are of known species introduced from other regions. *Fridericia peregrinabunda* Michaelsen, 1913 is peregrine in South & East Africa, Australia and Japan/Korea (Ref.), etc.

Habitats: Freshwater, marine, littoral or terrestrial in moist soil (e.g, *Enchytraeus, Cernosvitoviella, Mesenchytraeus, Cognettia, Marionina* Michaelsen in Pfeffer, 1890). Found in sewage filters (eg. Stephenson, 1933: 901). *Enchytraeus albidus* and *E. buchholzi* Vejdovsky, 1879 are often cultivated for fish hatcheries and aquaria food. Some species are epizoic on earthworms (eg. Coates, 1990).

Notes: Commonly called 'potworms' or 'whiteworms'. This group is sometimes included with the aquatic microdriles, rarely with the terrestrial megadriles, and is more often overlooked. Nevertheless, the enchytraeids are widespread and common; for example, the current author has found these small worms at most non-arid sites around Australia, NZ and Asia. Only ~650 spp are known, some reproduce by fragmentation.

Enchytraeids from sub-antarctic islands are described by Lee (1968), who noted that Commonwealth Bay, Antarctica is the southernmost record for soil Oligochaeta.

The current author (RJB) has identified *Marionina werthi* Michaelsen, 1905 and *Lumbricillus macquariensis* Benham, 1905 from Macquarie Island; plus *Marionina antipodum* Benham, 1905 and *Enchytraeus albidus* Henle, 1837 are also know there [Benham (1905, 1909) and Ref] along with three reported species of earthworms (Ref).

A new record by the current author is of *Claparedrilus semifuscus* (Claparède, 1861) (previously referred to *Lumbricillus* or *Pachydrilus*) from Korea, viz. WM14 Korea 1st survey RJB Feb., 2012 from smallest lumbricid – BLAST 100% MH882892 *Lumbricilus semifuscus* from Hengduan Mts., China; 2020.

AGTGTTGATATAAAATTGGATCTCCTCCCCCCGCAGGGTCAAAAAATG
AAGTGTTTAAGTTTCGATCAGTTAATAATATAGTAATTGCGCCAGCAAGAACT
GGAAGAGATAAAAGAAGTAAAACAACAGTAATTAGAACTGCTCATACAAAT
AAGGGAATCCGTTCTAAACGTAACCCGGCTCATCGTATGTTAATGACGGTGG
TGATAAAGTTAATTGCACCAAGAATTGAAGATGCACCTGCCAGGTGAAGGGA
GAAAATTGCTAGATCTACTGAAGGTCCAGCATGAGCAATATTTCTAGAGAGA
GGAGGGTATACAGTTCAACCAGTTCCAGCTCCTTTTTCTACTGCCGCAGAGG
ATACTAGGAGAATCAGTGAAGGAGGTAAAAGTCAGAATCTTATATTATTTAAC
CGAGGAAATGCTATATCTGGTGCACCTAGTATTAATGGAAGAAGTCAATTTCC
AAATCCTCCAATAAATACAGGCATAACTAGGAAGAAAATTATTACGAAGGCAT
GGGCTGTAACGATTGTATTATATAATTGATCCCTTCCTAAGAAAGCTCCAGGTT
GTCTTAATTCAATTCGAATTAGAAGTCTTATTCCGGCACCTACTATTCCGGCTC
AGACACCTAAAATAAAGTAAA

Because they are not ecologically as important as are true megadrile earthworms, nor are they as biodiverse or particularly interesting, thus enchytreids are not considered further in this work.

Selected References:

Benham, W.B. (1909). Report on the Oligochaeta of the subantarctic islands of New Zealand. In: Chilton, C. *The Subantarctic Islands of New Zealand* 1(12): 251-294.

Coates, K.A. (1990). Redescriptions of *Aspidodrilus* and *Pelmatodrilus*, enchytraeids (Annelida, Oligochaeta) ectocommensal on earthworms. *Canadian J. of Zoology* 68: 498-505.

Lee, K E (1968). Oligochaeta from subantarctic islands. *British, Australian and New Zealand Antarctic Research Expedition 1929–1931 Reports* Series B (Zoology and Botany). **8(8):**149–165.

Order **MEGADRILACEA** Benham, 1890

Megadrili *sensu* Gates (1962: 299), Sims (1978), Easton (1981), Blakemore (2008), etc. to include Family Moniligastridae within the group of these mainly larger and mainly terrestrial 'megadriles' (cf. 'microdriles'). Sims (1978) has Megadrilacea (Oligochaeta), also as '***Megadrilacea***' by Easton (1981: 33) which (Easton, 1981: 35 "*After Sims, in press*") comprises Orders Moniligastrida + Lumbricina or Haplotaxida. Although unregulated by the ICZN Code, Order **MEGADRILACEA** Benham, 1890 may be a more suitable conventional suffix than previous 'Megadrili'.

Sub-order **Exquisiclitellata** Blakemore, 2013 defined as those 'non-crassiclitellate' members of the super-order Megadrilacea (viz., Moniligastridae Claus, 1880, plus Alluroididae Michaelsen, 1900 and/or Syngenodrilidae Smith & Green, 1919).

Family **Moniligastridae** Claus, 1880

Moniligastridae Claus, 1880: 480; Vejdovsky, 1884; Rosa, 1888; Benham, 1890; Beddard, 1895; Michaelsen, 1900: 109; Stephenson, 1930: 813; Gates 1942: 87, 1972: 238; 1982: 17.

Note: Sometimes misspelt "Moniligasteridae".

Type-species and type-genus: *Moniligaster deshayesi* Perrier, 1872 from Sri Lanka.

Diagnosis: (from Michaelsen, 1900: 109; Stephenson, 1923: 140: 116; Gates, 1972: 238, 1982: 17): Lumbricine. Prostomium prolobous. Male pores one or two pairs (on 10 or in 10/11 or 11/12 and 12/13) behind spermathecal pores (in 7/8 and/or 8/9) and in front of female pores (in 11/12 or near 12/13 or 13/14). Testis and male funnels in intraseptal (or intersegmental septal) sacs. Gizzards multiple (e.g. 2-12 of in region of segments 11-34) behind ovarian segment. Nephridia holoic. Clitellum unilayered. Ova macrolecithal (i.e, with large yolk-particles). Spermathecae have long tubular ducts. (Last hearts in 9?).

Distribution: Southeast and eastern Asia, from Sri Lanka to eastern Siberia, also Korea, Japan, the Philippines, Borneo and Sumatra. Several *Drawida* species have been reported outside the generic range, several of these later synonymized (below), but most moniligastrids are probably confined to their areas of origin in the Indo-Asian region (Gates, 1972, 1982: 18 - who says most species tolerate dry soils and are adverse to human activity). Approximately 200 species are currently known.

Desmogaster sinensis Gates, 1930 is supposed to be abundant as a rather recent

introduction in cultivated soil in the lower Yangtze Valley region at Soochow and Wu-sih, Kiangsu province, China (Chen, 1933; Gates, 1939: 406; 1972: 241).

Monotypic East African *Syngenodrilus lamuensis* F. Smith & Bessie R. Green, 1919 from "*Mkonumbi near Lamu, British East Africa* (Kenya)", listed by Stephenson (1923; 1930) as Syngenodrilinae under Moniligastridae but also elevated to family level as Syngenodrilidae, is now (along with *Alluroides* Beddard, 1894: 252 for *Alluroides pordagei* Beddard, 1894: 244, pl. 16-17, figs. 4-5 from swampland opposite Mombassa and *A. tanganyikae* Beddard, 1906: 215) usually accommodated under the microdrile affinity family Alluroididae Michaelsen, 1900: 106. Alternatively, both latter families are retained under superfamily Alluroidoidea distributed in tropical East Africa and Africa/S. America, respectively (e.g. Gates, 1945: 393; 1972: 48; Pickford, 1945: 397; Zicsi & Csuzdi, 2000).

Remarks: Stephenson (1923: 117; 1930) considered the characteristic intraseptal testis sacs of Moniligastridae "*as the morphological equivalents of segments ... The ancestor of the family probably possessed three pairs of testes, in segments x, xi, and xii*;.." and these multiple original testes arrangements now result in the double or single pair of intraseptal sacs likely developed from ancestral septa.

In *Drawida* it is precisely the ontological combination of septa 9/10 and 10/11 plus their displacement to mid-segment 10 internally as septum 9/10, along with the successive septa "11/12" and "12/13" that themselves combine (dorsally at least) to encompass the ovarian segment and are now 10/11 (and perhaps 11/12) that confounds segmental counts of organs in these segments. Compared to the external segmentation, the internal segmentation differs. Obviously a different method of segmentation counting is needed for *Drawida* species, perhaps relative to position of ovaries, but historical accounts are inconsistent. Deciphering actual internal counts is therefore particularly difficult for most, if not all, species. My suggestion is to fix internal counts relative to eternal segmentation not to the septa.

This problem was noted much earlier: when Horst (1894 Notes From The Leyden Museum16:137-144(1894) http://biostor.org/reference/98243 : 139) said:

"*As first stated by myself in* Monilig. Houtenii*, so also in the present species the internal segmentation does not correspond to the external one, due to the shifting of several septa. Benham observed the same feature in* Moniligaster indicus*, and according to Rosa it occurs also in* Desmogaster. *The shifting commences with the ninth septum, that instead of being inserted in the intersegmental groove IX/X* [9/10]

is attached to the body-wall about in the middle of segment X [10]*; the next following septum is nearly thrown back a whole segment and is inserted close to the hinder boundary of segment XI* [11]. *In other Moniligaster-species the tenth and eleventh septum meet with each other and are confluent along a part of their surface; in the enclosed space the ovaria and the oviducal-funnel are situated.*"

Key to Moniligastridae (from Gates, 1972; Blakemore, 2008)*

1. Female pores at or just behind 13/14, ovaries in 13 2
   Female pores and ovaries more anteriorly 3
2. Male pores at 11/12 and 12/13 ..... *Desmogaster*
   Male pores at 11/12 only ..... *Hastirogaster*
3. Female pores at or just behind 12/13, ovaries in 12 ..... *Eupolygaster*
   Female pores at or just behind 11/12, ovaries in 11 4
4. Y-shaped glands on spermathecal atria ..... *Moniligaster*
   Y-shaped branched glands lacking ..... *Drawida*

*A descriptive problem is that septa progressively encroach backwards around ovaries. Gates (1972: 241) seems to have made a mistake in calling the spermathecal atria Y-shaped rather than the glads which attach to them that are Y-shaped glands; Michaelsen (1900: 110) requires only that the spermathecal atrial gland be pedunculated, i.e. stalked.

Michaelsen (1900), Stephenson (1923) and Gates (1972) provide limited keys to species.

Genus **Desmogaster** Rosa, 1890

Type-species: *D. doriae* Rosa, 1890 from Leiktho Circle, Myanmar. Types in Genoa although a mislabeled specimen of unknown origin was for some time on display at the Agassiz Museum, Harvard according to Gates (1972: 242).

Diagnosis: Male pores at 11/12 and 12/13. Female pores near b lines near 13/14. Testes in 10/11 and 11/12. Ovaries in 13. Spermathecae adiverticulate. Gizzards multiple.

Distribution: Myanmar, Borneo, Sumatra, and China (by introduction?).

Nine species; as noted above, one thought introduced in China is ***Desmogster sinensis*** Gates, 1930 that is thus probably classifiable as peregrine.

Desmogaster sinensis Gates, 1930

Desmogster sinensis Gates, 1930: 590; Chen, 1933: 180, figs. 1-2; Gates, 1939: 406; 1972: 241. [Type locality Soochow, type in "*author's collection*"].

Distribution: From Tiger Hill at Soochow among ancient ruins and from other low hills in the vicinity, not known in region intervening between congeners in Myanmar (Chen).

Diagnosis: Colour light yellowish. Size 290-540 by 8-12 mm (Chen's specimens were smaller). Setae may be completely absent (Gates, 1939). Two pairs of spermathecae posteriorly in 7 and 8. Male pores, two pairs in 11/12 and 12/13. Dorsal pores absent. Prostates sessile but with glandular investment. Vas deferens passes directly into prostate rather than looping via parietes. Gizzards, three (or four) in 14-16,17.

Genus ***Drawida*** Michaelsen, 1900: 114

Type-species: *Moniligaster barwelli* Beddard, 1886 by original designation.

Diagnosis (from Michaelsen, 1900: 114; Stephenson, 1923; Gates, 1937, 1962, 1972, 1982: 18; Blakemore, 2002; 2008): Small to 'giant' (>1,000mm) terrestrial earthworms. Setae lumbricine [said to have a "*smooth body without setae*" in ***Drawida zhangetalia*** Blakemore, 2006 nom. nov. pro *Drawida cheni* Zhang et al., 2006 (non *D. cheni* Gates, 1935) that was described as similar to *Drawida zhongi* Blakemore,2006 nom. nov. pro *Drawida sulcata* Zhong, 1986 (non *D. sulcata* Michaelsen, 1907); cf. *D. victoriana* Gates, 1962: 352 also laking setae in anterior]. Dorsal pores absent (or intermittently present, e.g. in *D. barwelli*, and D. *japonica*, pers. obs.). Clitellum includes segments 10-13 but extent often obscure. Male pores in or near 10/11. Female pores in or near 11/12. Spermathecal pores at 7/8 (spermathecae without Y-shaped "*dichotomously branched glands*" of *Moniligaster*). A pair of testis and male funnels in intraseptal sacs on or in 9/10. Short or sessile 'pseudo-prostates' present in 10. Ovaries in 11, with a pair of ovisacs from septum 11/12 extending posteriorly. Last hearts in 9. Several (two to eight, or nine in *D. hattamimizu* Hatai, 1930) moniliform, intestinal gizzards within segments 11-27 (or 27-34 in *D. nilamburensis*). Holoic (and sometimes vesiculate). With "*paired "enterosegmental" organs on the intestine dorsally*" (Gates, 1972: 238) but oesophageal gizzards, calciferous glands, typhlosoles and intestinal caeca absent.

Taxonomic Note: Gender of *Drawida* name was not initially stated, but Stephenson (1923: 153) retained it as feminine as first established by Michaelsen's combination of

adjectival species-names, and Easton (1984: 111), citing ICZN articles (now 1999: Art. 30.1.4), proposed to continue to treat it as feminine. Michaelsen (1900: 114) told us it was named after "*the native community of East-India*" and, even though "*Drawida*" – the German name for the Dravidian people of southern India/Sri Lanka – is of variable gender as it seems to take either "der" (m) or "die" (f) (cf. ICZN, 1999:Art. 30.2.1) and Michaelsen (1931b: 7) later told us "*It was a mistake that in spite of that I wrote the species description for a female form*". However, as no gender was specified, and both the original the species-group adjectival names and the genus name end in *–a*, the gender is confirmed as feminine (ICZN: Arts. 30.1.4.2, 30.2.3-4). Note: *Drawida omeiana* Chen, 1946: 84 is mislabeled "*omeimontis*" in his Plate IB.

Distribution: Indo-Asian region, very widespread: "Drawida *has a self-acquired range which may only be exceeded by that of the Lumbricidae, and is larger than that of the* Pheretima s. lat. *domain, consequently it is expected to yield proportionately more species... Possibly,* Drawida *alone may prove to have the greater number of species*" (Gates, 1972: 238-239). Currently about 200 taxa are known (Csuzdi, 2003; Blakemore, 2014). Described by Stephenson (1923: 118, 124, Chart 1) as "*one of the large Indian genera*", its headquarters appears to be in Sri Lanka, southern India, eastern Himalayas, and Myanmar. At least one supposed native, *Drawida ghilarovi* Gates, 1969 from the Russian far east in south-east Siberia, is listed on their Red Data Book.

Relatively few species apart from *D. barwelli* are peregrine: *Drawida japonica* (Michaelsen, 1892) has been reported from the western Indian Himalayas, Yunnnan and Szechuan in China, from Japan and Korea, and is also found on Taiwan (cf. *D. ramnadana* Michaelsen, 1907 from south India); *D. koreana* is described from Korea, China, Japan and, from DNA barcodes, its sub-species are are found on Japan and on the Matsu Islands of Taiwan (see Blakemore *et al*. 2014; Ref.); *Drawida parva* (Bourne, 1894) poorly described on South Indian specimens was claimed to be on the Moluccan Aru Island west of Irian Jaya and Stephenson (1923: 150) thought it possibly identical with his *D. parambikulamana* Stephenson, 1915: 150 while Gates (1972: 244) calls it "*sp. dub*."; Himalayan *D. nepalensis* Michaelsen, 1907: 146 (syn. *D. burchardi* Michaelsen, 1903: 7, etc.) from Indagiri, Sumatra is found in Nepal, India, Pakistan (e.g. Lahore), Myanma, China (Yunnan), Andaman Islands, and Java (Buitenzorg) (e.g. Gates, 1972; Hairiah *et al*., 2001: 20); *Drawida impertusa* Stephenson, 1920 (previously a sub-species of *D. barwelli*) from Bombay and Philippines cf. *D. bournei* (Michaelsen, 1897) that Stephenson (1920: 202) says Michaelsen thought was itself a variety of *D.*

pellucidus; *D. longatria longatria* Gates, 1925 (syn. *straeleni* Michaelsen, 1930: 4 – see Gates, 1937: 309; 1962: 326; 1982: 18) from Myanmar, probably introduced to Sumatra (Gates, 1965; 1972; 1985); *D. gisti gisti* Michaelsen, 1931 from China and Korea (see Gates, 1935: 2; Gates, 1939: 306, Kobayashi, 1938: 95; 1940: 271, and Chen, 1959: 16, fig. 23 for description of types); *D. vulgaris* Gates, 1930 from Myanmar and Chiengmai, Thailand (at 1,000 ft); and *D. delicata* Gates, 1962 (possibly a synonym of *D. barwelli*) is from Myanmar and Vietnam. *Drawida papillifer* Stephenson, 1917: 370 from India and Myanmar is now a junior synonym of *D. hodgarti* Stephenson, 1917: 366.

Large and handsome *Drawida hattamimizu* Hatai, 1930: 485 (misspelt "*hattaminizu*" in Reynolds & Cook (1976: 111) has local distribution in Kanazawa (type locality and pers. obs.) and in Kinki around Lake Biwa in Japan where its transportation is restricted by legislation due to its large burrows supposedly draining paddy embankments. The record from Hokkaido by Easton (1981) is a mistake. Possibly it is an introduced, or at least translocated, species with a patchy distribution but with no intervening biogeographic boundaries. Its types are not located and I designated and described a neotype in Blakemore *et al.* (2010) definitively combined with DNA profile.

The largest species, already alluded to above, are *Drawida grandis* (Bourne, 1887: 671) and *D. hattamimizu* (Hatai, 1930) that both extent to about 1,000 mm (Ref.). *Drawida naduvatamensis* (Bourne, 1894: 361) Nadivata, Nilgiris Hills, Tamil Nadu and *Drawida nilamburensis* (Bourne, 1894: 362) are about 500-750 mm long. Species measuring 90-220 mm by ca. 5 mm wide (stated to be 15.6 mm in circumference) are *Drawida uniqua* (Bourne, 1887: 671) (originally *Moniligaster uniquus*) that includes *Moniligastger papillatus* Bourne, 1887" 672 (non *D. papillifer* Stephenson, 1917) as a junior synonym; and *D. pellucida* (Bourne, 1894: 363) for which Stephenson (1923: 144) thought *D. kempi* Stephenson, 1914: 376 may be a variety of. Moreover, *D. uniqua* was thought possibly a "*hybrid*" of his *D. sapphirinaoides* (Bourne, 1887: 672) according to Bourne (1894: 363-371, fig. 4) who also thought his *D. pellucida* (Bourne, 1894: 363, fig.s 3, 30) (originally *Moniligaster pellucida*) may form "*hybrids*" thereby all possibly meriting synonymy. Nevertheless, Michaelsen (1900: 118-120) maintained all three of these species separately but listed sub-species of *D. robusta* whereas Stephenson (1923: 150), while listing many sub-species, thought that they were all varieties and, finally noted on page 152 said they mostly belonged to a group related to *D. barwelli*. [Note: that Bourne (1894: 363) confirmed that the 'male papillae' of *papillatus* were extruded male pores as often found, as Beddard, 1895

thought; also Reynolds & Cook, 1976 overlook *papillatus* completely and misdate *uniqua* as "1894"]. See Bourne's 1894 figs. here.

One of the most widely distributed, though rarely collected due to its small size, is *D. barwelli* (Beddard, 1886) that is often reported under its junior synonym *D. bahamensis* (Beddard, 1893) that was first obtained in soil brought to Kew Gardens. Perhaps originating in China or Myanmar, it occurs throughout the tropics, e.g. from India, the Caribbean, Philippines, Indonesia, Caroline Islands, Fiji(?), Tonga, Samoa and Soemba (Beddard, 1886; Gates, 1972; Easton, 1984). The report of this species by Blakemore (1994a; 1999) represented the first introduction record for a moniligastrid in Australasia.

It is probable that *D. japonica* is a closely related species, and the two have exchanged sub-species, as, apart from the genital markings, penis, and gizzard variabilities, it agrees tolerably with *D. barwelli* diagnosis (as provided below). All the more probable if the uneven "markings" in *D. japonica* actually prove to be parasitic artefacts as I suspect. In some other species genital markings are undoubtedly functional.

Allowing for the contingencies noted above, what Keys to species exist are by Michaelsen (1900: 114-115) as online here or paged here, Stephenson (1923: 127-133), and Gates (1972). No-one seems to have attempted taxonomic revision of this complex group since, and here I limit myself to present a best attempt at unravelling some of the difficulties in describing the few known or reported cosmopolitan species.

In lieu of a meaningful key to peregrine species, below is a table of key characteristics (from Tab. 3); however most species and identities are complex requiring more work:

Key characters of prioritized *Drawida* listed in Japan/Korea and elsewhere.

***Drawida* spp. / Character**	***barwelli* (Beddard, 1886)**	***japonica* (Michaesen, 1892)**	***nemora* Kobay., 1936**	***koreana* Kobay., 1938**	***keikiensis* Kobay., 1938**	***ofunato-ensis* O., 1938**	***taira-ensis* O., 1938**	***morioka-ensis* O., 1938**
Colour	Pale/unpig-mented	Grey/pale	**Dark bluish**	**Dark blue**	Yellow/grey	Dark yellow	Flesh red	Dark lead grey
Size (mm)	20-65	28-130(200)	65-185	63-100	40-54	**228-283**	59-92	65-100
"GM"s	**None**	7-13 **I**	6-13 (**I**)	7-12 **I**	**None**	7-13	8 **I**	**None**

DPs	Yes/No	Yes/No	No	No	No	No	?	?
Gland in 7	No	No	**No/Yes**	No	**Yes**	No	**Yes**	No
Form of Male Pores	Penis in pouch	**Flap or stubby porophore in 10**	Penis in small pouch	**Flap or penis-like porophore in 10**	Penis in pouch	Penis in pouch	Penis in pouch	Penis in pouch
Gizzards	**2-4**	**2-3**	**3-5**	**2-3**	**3-4**	4+ (?)	4	**2-3**
Gizzard Segments	12,13-14,15(,16)	(11,)12-13,14	12,13-15,16	12-13,14	12,13-15	12-15,16?	13-16?	10,11-12

Kobay. – Kobayashi; O. – Ohfuchi; GM – genital marks; I – irregular 'markings'.

NOTE: *Drawida beddardii* requires separation from synonymy in *Dr. barwelli* but *Dr. keikiensis* from Korea is a likely synonym of *Dr. syringa* Chen, 1933 from China (Ref).

Drawida barwelli (Beddard, 1886)

Fig. 1.1 *Drawida barwelli*, Samford (Qld, Australia) specimens (a) ventral view (b) cocoon, (c) enlargement of testis sac on septum with convoluted vas deferens to 'prostate' on copulatory chamber, (d) dorsal view of prostomium; (e) spermatheca and (f) male organs and distended egg sac shown in relative position to (g) a lateral view (the dorsal blood vessel and eggs sac visible through cuticle).
Fig. 1.2 *Drawida barwelli*, two amphimictic Samford specimens just separated.
Fig. 1.3a *Drawida barwelli* after Beddard (1896, Pl. II, figs. 4-6).
Fig. 1.3b *Drawida barwelli* (*D. bahamensis* after Beddard, 1893, Pl. XLV).
Fig. 1.4 *D. barwelli*, live specimen compressed between two glass slides, photo 1 (RJB).
Fig. 1.5 *Drawida barwelli*, photo 2 (RJB).
Fig. 1.6 *Drawida barwelli*, zoom of gizzards, photo 3 (RJB).

Moniligaster barwelli Beddard, 1886: 94, figs. 4-6; Beddard, 1887: 678; [?Beddard, 1888: 119, figs. 10-12]; Beddard, 1889: 534; [?Beddard, 1891a: 2, 12?, figs. 1-10]; Beddard, 1893: 692; Bourne, 1894: 374; Beddard, 1895: 200 (syns. *beddardii* Rosa, 1890, *M. sp.* Horst, 1893) (part.). [Type locality "*from the neighbourhod of*" Manila, Luzon, P.I.; Gates (1937: 307) said the twenty aclitellate syntypes were either dissected, sectioned or mounted between 1886-1891 and he questioned whether any were undispersed. Types in British Museum (BMNH 1904:10:5:522-3) were disputed by Easton (1984: 112) who re-described the species from new material after finding that the type series, that he labelled "*(BMNH: 1904:10.5.2-3)*", comprised a posterior portion and an

associated slide that produced no useful data (although DNA is possibly retained?). See also note below under 'Material Examined' for BMNH 1974.1.101-102].

?*Moniligaster beddardii* Rosa, 1890: 379. Non *Moniligaster beddardi* Gates, 1940: 496 (= *Moniligaster cernosvitovi* Gates, 1962: 35 nom. nov.) from Kodaikanal, India. [Locality "*Villagio di Chiala" 1400-1500m (Carin Padaung o Asciuii Ghecu)*", somewhere in Burma this village being untraceable (Gates, 1962: 312). Types missing (from Genoa?)]. [This now likely a separate taxon to *barwelli*].

?Drawida beddardi : (sic) Gates, 1962: 312; 1972: 246 (syn. *D. barwelli* var. *hehoensis* + *D. "fluvaitilis"* Stephenson, 1924: 324 + 325; *D. tecta* Gates, 1926, all from near Yaungwhe). [Gates (1962, 1972) appears to reject synonymy of *beddardi* in *barwelli* but this one of his many reversals as Gates (1929: 3) had previously noted that *Moniligaster beddardii* was the same as *Drawida barwelli*].

?*Moniligaster sp.* Horst, 1893: 46. [A specimen from the isle of Flores]; Gates, 1965: 86.

Moniligaster bahamensis Beddard, 1893: 690, figs 1-5; Beddard, 1895: 202. [Type locality (under ICZN, 1999: Art. 76.1.1) Bahamas from where imported with plants to Kew. Types supposedly two specimens, now missing (Gates, 1982: 18) and not registered in BMNH, London (A. Cabrinovic adc@nhm.ac.uk pers. comm. 24.III.2010 and a personal search in 2013) although Coles (1981: 302) yet lists them as in BMNH].

Drawida bahamensis: Michaelsen, 1900: 118; Gates, 1954: 241; 1965: 85 (syn. *Moniligaster* sp. Horst, 1893; *D.* "*japonicus*" f. *bahamensis*: Michaelsen, 1910c: 50). Cf. Gates (1982: 18) who maintains *D. bahamensis* separately and claims two specimens from Puerto Rico, 33 from Calayan Island, Philippines, one adolescent from Nicaragua and some from Honolulu in earth from Tonga.

?[*Moniligaster parva* Bourne, 1894: 371, fig. 11. Type locality Ootacamund, southeast India; type material not known; also reported from Aru Islands near West Papua].

Drawida barwelli (some in part?): Michaelsen, 1900: 116 (syn. *beddardii* Rosa, 1890; ?*Moniligaster sp.* Horst, 1893); Michaelsen, 1910a: 51 (part, residue lacking dorsal pores is what will become known as *D. impertusa*); Michaelsen, 1922: 6; Stephenson, 1923: 133 (part, residue = *D. impertusa*); Gates, 1929: 3 (syn. *beddardii*); Gates, 1937: 307-309 (where he gives a good account and corrects many of Beddard's mistakes); Gates, 1965: 87, 93) [syn. ?*D. parva* (Bourne, 1894), ?*D.* "*parvus*": Michaelsen, 1901]; Gates, 1962: 312 (where he

restores *beddardi*); Easton, 1984: 112, fig. 1g (syn. *D. bahamensis*, ?*D. parvus*: Michaelsen, 1910 non Bourne, 1894 but Easton apparently rejects or ignores the *beddardii* synonym that was apparently restored by Gates, 1962: 312); Blakemore, 1994; 1999; 2000, 2005; 2008; 2010 (syns. as herein).

?Drawida parvus (sic): Michaelsen, 1910b: 25; Gates, 1965: 93 [?non *Moniligaster parva* Bourne, 1894, nec *D. parva* (Bourne, 1894): Michaelsen, 1900: 118].

?Drawida barwelli var. *hehoensis* Stephenson, 1924: 324. [From Heho Plain near Yaungwe; Gates 1931: 340; types stated by Gates (1972: 246) to be in Indian Museum; listed by Reynolds & Cook (1976) as BMNH: 1925:[5:?]12:34, and ZSIC Calcutta 1107]. [Cf. *D. gisti* Michaelsen, 1931: 525 and its subspecies *D. g. nanchangiana* Chen, 1933: 200 and *D. g. anchingiana* Chen, 1933: 202 especially by Gates, 1935: 2; 1939: 408].

?Drawida fluviatilis Stephenson, 1924: 325. [Also misspelt "*fluvaitilis*"; from White Crow stream near Yaungwe; types stated by Gates (1972: 246) to be in Indian Museum; listed by Reynolds & Cook (1976) as BMNH: 1925:5:12:120].

?Drawida tecta Gates, 1926: 148. [Type locality Yaungwhe. Types in US Natl. Mus.].

?Drawida sp. Gates, 1930: 298. [Later named as *D. delicata* Gates, 1962: 319].

Drawida glabella Chen, 1938: 377, fig 1. **Syn. nov. by Blakemore (2006).** [From Sha-moh-chiu, Hainan; type not known but only one specimen]. [There is nothing to separate this specimen's description nor figures from the following description, expept perhaps that dorsal pores are stated to be evident behind the clitellum and the male atrium's "*glandular portion probably enclosed by peritoneal sheet (not to be sectioned)*" (nor figured). Chen says his specimen lacked accessory glands to spermathecae. However, the description is yet somewhat similar to *D. japonica*].

[?*Drawida delicata* Gates, 1962: 319. From Myanmar. Types lost. **Syn. nov.?**].

Drawida borwelli : laps. Global Names Index, 2010 (www.globalnames.org/name_strings?search_term=borwelli&commit=Search).

Non *Drawida barwelli*: Cognetti, 1911: 494 (= *D. impertusa*: Gates, 1965: 87) nec *Drawida barwelli impertusa* Stephenson, 1920: 200; Stephenson, 1923: 134 (= *D. impertusa*: Gates, 1965: 87).

Taxonomic Note: Beddard originally miscounted the segments, combining the first and second so that all his counts were out by one; this eventually corrected e.g. by Beddard (1891) - see Gates (1937). The "*atrium*" in many diagnoses is the spermathecal opening

but more usually refers to the male opening, or sometimes to both.

The synonymy of the species is complicated, in broad summary:

1886 Beddard described *barwelli*.

1890 Rosa described *beddardii*.

[1892 Michaelsen described *japonica*; augmented by redescription in 1931].

1893 Beddard described *bahamensis*.

1894 Bourne described *parva* from South India.

1895, 1900, 1923, 1929 - Beddard, Michaelsen, Stephenson and Gates **included *beddardii* in *barwelli***.

[1910-1923 Michaelsen and Stephenson placed *bahamensis* in *japonica* but keep *parva*].

1931 Michaelsen reversed himself and said "*It is incomprehensible that* D. bahamensis *and* D. japonicus (sic) *should be united;* D. bahamensis *has in the male atrium a clear muscular penis pouch with a clear if not very long penis*" unlike *D. japonica*. [Afternote: current studies (by RJB) appear to support this conclusion].

[Gates, 1940 inadvertantly named an unrelated Indian species *M. beddardi* that he later provided with a replacement name of *M. cernosvitovi* Gates, 1962: 355].

1962 Gates maintained *barwelli* and *beddardii* separately.

1965 Gates maintained *barwelli* and *bahamensis* separately.

1972 Gates reversed his earlier (1929) statement and regarded *barwelli* as sp. dub. separate from *beddardi(i)* which he redescribed.

1984 Easton **again synonymized *bahamensis* in *barwelli***, but appears to have excluded *beddardii* and *hehoensis*, and provisionally retained *parva* in part.

1999, 2002, 2008, 2010 Blakemore **reunites *barwelli* with *beddardii* and *bahamensis*** plus add other synonyms and tries to resolve this complex issue definitively.

2012-2014 Blakemore questions inclusion of *beddardii* based on new information.

2018 Shen reaches same conclusion (but despite claiming clarity provides no DNA!).

Material Examined: In May, 2010 I received the BMNH types, apparently now numbered 1974.1.101-102 and labelled: "*Moniligaster barwelli TYPE 1974.1.101-102 Loc. Manila, Philippines Coll. Mr H*[erbert]. *E. Barwell Ref. Ann. Mag. Nat. Hist. 5 xvii p. 74"* and *"Beddard 1886 Manila, Phillipines [sic] Collector: H.E. Barwell*" plus another note: "*These fragments are far too large to be types of M. barwelli which is less than 40 mm long EGE*[aston] *April, 1981*". This material comprised one tail portion with the anterior end cleanly cut (length = 35mm, segments = 152) and one mid-

portion that is cleanly cut at both ends (length = 30mm, segments = 198), both blackened and neither yielding useful information but small tissue samples were taken from each for COI barcoding, 26.VIII.2010 that was, unfortunately, not successful on this old material. This material was reinspected by RJB VI.2013 and details confirmed as possibly yet syntypes (Blakemore, 2014).

Registration No.: Type material listed above, although further note that Coles (1981) said syntypes were two specimens and a "*micro-slide*" (Ref.) that is unlocated. Australian material: ANIC: RB.95.4.1, numerous specimens collected at Samford, Qld (27°22'S,152°53'E) by RJB in 1992.

[The following description is based on earlier accounts (above) augmented by material collected by the author from a farm at Samford, Qld; some specimens were preserved and dissected, others were observed alive, gently compressed between glass plates (see photos 1-3 above), to confirm identity of those used in glasshouse experiments].

Diagnosis (from synonymy above and pers. obs. with **definitive *barwelli*** characters bolded to separate from *beddardii* etc. competing synonyms)**:** Pale. Size 20-66 mm. Setae 8 per segment but often small on segment 2 which causes other segments to be miscounted. Clitellum 10-13. Pale colour. Dorsal pores (intermittently) present or typically **absent**. Genital markings **absent**. Gizzards usually two or **three, or four** in 12,13-14,15(,16,17) (claimed by Shen to be "*XIV-XVI*", i.e., 14-16 only; but, despite this "confidence"/arrogance, this is obviously false when compared to true Nature as in my much more detailed and informative specimens' description below). Male pore on tips of penes in copulatory pouches in 10/11. Spermathecal pores 7/8 in bc. A wide difference in diagnoses of internal genital details is partly due to stage of maturity of described specimens/species.

Dorsal pores are said, variously, to be absent, intermittently present in *D. barwelli* e.g. by Stephenson (1923: 133), or present in its rejected synonym *D. beddardi*. They are also sometimes present in *D. japonica* (pers. obs. of Aichi specimens and newly found by Blakemore in Blakemore & Kupriyanova, 2010: 13 in its type!) thus this character seems variable in this species group. DPs also found in *D. paradoxa* Rao, 1921: 528 that, although lacking GMs and having gizzards in 12-15 (i.e. four of) is perhaps a bit larger at 96 mm with a distict copulatory pouch by its spermathecae.

Distribution: The original home is thought to be in the Indo-China region (Gates, 1972); e.g. India (Travancore – homeland?), Myanmar (homeland?), also found in the

Philippines (e.g., Manila and, from Gates, 1982: 18 from Calayan Isl.), England (at Kew Gardens imported with plants from Bahamas), Sumatra, Maros karst area of Southern Sulawesi (Ref.) and south Bihn Dihn Province, Vietnam (Ref. as *D. beddardi* and *D. delicata*); various Pacific Islands (Easton, 1984) e.g. Jap Island (Carolines), Tonga (Gates, 1982: 18; and Ref.), Samoa (e.g., Vargo, 1999), ?Flores, ?Aru I., Lombok; possibly from Papua New Guinea (Standen, 1988); in Neotropical region from Cuba, Puerto Rico (e.g. Gates, 1982: 18 from Cidras, at 1200 ft.) and Jamaica in the Caribbean, Mexico, and Nicaragua (Gates, 1982: 18 – as the first record of an earthworm from that country "*From soil about roots of avocado plant supposedly from Nicaragua, arriving by plane at Brownsville, March 4, 1957*", and Fragoso pers. comm.). Juan Fernandes in Atlantic (Gates, 1969). The **new** Australian record is from Samford, Qld (Blakemore, 1994). A **new record** for Thailand is from description and figure unrecognized as diagnostic by authors [Kosavititkul, P. & Wannititkul, P. fig. 1F tab. 1 Ref. and by Somniyam, P. & Suwanwaree, P. (2009), plus Choosai *et al*. (2010) where it is identified as *D. beddardi*] and from Blakemore (2007). Hainan (*D. glabella*) is also a **new record** although this is disputed in a new claim of *D. barwelli* from Taiwan (Ref.). [**Note:** an interesting feature of some Lake Biwako worms, named *D. eda* Blakemore, 2010, is that several specimens had the rhs male apparatus everted completely, the lhs organ was either invaginate or only the tip of the penis was visible; this is the same as for one specimen of *D. bahamensis* from the Juan Fernandez Isles described by Gates (1969), possibly a misidentification but nevertheless it may thus be a useful identification characteristic to support identification within this species group].

Habitats: In alluvial sandy-loams and alluvial-prairie intergrades under pasture and near tree plantation (Samford); rice fields in Japan.

Behaviour: Fairly docile when handled. Specimens were found coiled in soil cells at about 10 cm depth when quiescent in dry soil in Samford. Gravid specimens were prevalent only in the late summer rainy season March-May in Queensland (Blakemore, 1994; cf. in Asia where Gates (1972) reports *Drawida* breeding period in the rainy season August-October).

Length: Current Qld specimens 30-65 mm (cf. Easton 20-66mm; up to 75 mm; thus range is 20-75 mm).

Width: 1-2.5 mm (cf. Easton 1.5-4 mm).

Segments: 98-118 (cf. Easton, 105-163), anterior segments have wider anterior flange, postclitellar segments a wider posterior flange; secondary annulation after 13 or 14.

Colour: Unpigmented, when alive it is transparent and soil is visible in gut (see photos), but it appears gold-brown (combination of yellow coelemic cells and red blood vessels) when aestivating. Dorsal lobes of yellowy egg sacs seen through epidermis in clitellar region extending from 10-14 during breeding season (ca. March-May in southeastern Qld - pers. obs.). When preserved it may be more opaque.

Prostomium: Prolobous, separate (cf., Easton has "*epilobic*" although he may mean prolobic).

First dorsal pore: None found in current specimens, although sometimes dark-spots seen dorsally, e.g. in 10/11. [Note: While separating *impertusa* that lacks dorsal pores, Stephenson (1920, 1923, 1930) and Gates (1972) repeat Beddard's statement that *D. barwelli* has dorsal pores, while Easton (1984) noted mid-dorsal intersegmental pigment spots that may easily be confused with them; it is equally possible that this is really an intermittent character as in *D. japonica* - pers. obs. of Aichi specimens and of it stype].

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment: small, closely paired from segment 2 (always present on 2?); (ratio variable, mean ca. 8:1:8:1:36:0.5).

Nephropores: Anterior margin of segments in c or d lines, especially clear from 4 to 15, with those in 13 most obvious.

Clitellum: Thin and indistinct in 10-13 but possibly just extending into adjacent segments.

Male pores: Paired on furrowed tips of small eversible penes within copulatory chambers having slit-like apertures with large tumid lips in 10/11, ca. 0.3 body circumference apart in bc lines but closer to c lines than to b lines. [**Note:** as already mentioned above an interesting pers. obs. feature of the Biwako worms named *D. eda* Blakemore, 2010 is that several specimens had the lhs male apparatus everted completely, the rhs organ was either invaginate or only the tip of the penis was visible; this is the same as for one specimen from the Juan Fernandez Isles described as *D. bahamensis* by Gates (1969) and it may thus be a useful identification characteristic to support identification].

Female pores: Paired at anterior margin of 12 lateral to b lines (not always obvious).

Spermathecal pores: Pair in 7/8 concealed in intersegmental fold, ca. 0.3-0.4 body circumference apart and just wider than male pores in bc but closer to c lines. [Beddard, Michaelsen, Gates, and Easton, have them variously between bc, in c, or in cd lines although it is not explained by Easton how their "*large transverse apertures*" can be accommodated "*half-way between setae c and d lines*" when setae c and d are so closely

paired and I suspect that Easton really meant "*half-way between b and c lines*", especially since his Fiji specimens had them slightly median to c lines]. In summary, they are in **7/8 in bc near to c**.

Genital markings: None, but centered around the male pores, especially their anterior and posterior margins, are large whitened pads (Easton and current Samford specimens). [Cf. a specimen from Watarase, Japan that ageees with *D. barwelli* on each other character except two "GM"s were noted in 9lhs posteriorly and 10rhs anteriorly, both lateral of b lines; thus more likely *D. japonica* that usually has distinctive disc-like markings/artefacts; plus the male pore I thought "on eversible penis lateral to b" is probably my mistake and it should be a porophore, i.e., qualifying as *D. japonica*].

Septa: 4/5 deleted (?), 5/6-8/9 thickened, 8/9 the thickest, 9/10/11/12 reduced and converged, the rest thin.

Dorsal blood vessel: Single (visible through body wall), not traceable on pharynx.

Hearts: Paired laterally in (6),7-9.

Gizzards: Variable, three small, spherical and moniliform gizzards usually in **12,13-14,15** (RJB: three in 12-14, first gizzard reduced or absent in only two of about a dozen Samford specimens inspected; Michaelsen: three in13-15; Stephenson three or four in 13,14-15,16). [Beddard originally reported four gizzards, later he changed to three in 13-15; Gates and Easton have three or four within 12-15,16; Gates (1969) has three or two in 12,13-14; however, for his *D. beddardi* description Gates (1972: 246) claims "*Gizzards, 3-4 in xii-xix*" [this likely a typical error for those insisting upon Roman numerals rather than more familiar Arabic for crucial segment counts!!] and if so would extend the permissible variation. Cf. the similar *D. bullata* Gates, 1933 (syn. *fucosa*) with "*Gizzards, 1-3 in xv-xviii*" and his earlier *D. flexa* Gates, 1929 and *D. gracilis* and *D. rara* both by Gates, 1925 with 3-5 gizzards in "*xvi-xxii*" and 2-4 gizzards in "*xiv-xx*" and 2-4 in "*xii-xviii*", respectively (Gates, 1962); and gizzards vary greatly in several other of his "species". Thus, a highly variable and often overlapping character possibly not as definitive as earlier thought, or else Gates was arrogant, unreliable and possibly insane].

Calciferous glands or diverticula: None.

Intestine origin (caeca, typhlosole): Possibly from ca. 20, (no caeca nor typhlosole). [Gates has intestinal valves in 19, 20 and origin in 19-21, Easton has intestine in 19. Naturally the intestinal origin also changes concomitant with the shifting gizzard series].

Nephridia: Large, avesiculate holonephridia seen from 4 (Easton, from 3), most obvious as simple tubes after clitellum (possibly absent from 10, but nephropores apparently

retained).

Male organs: Testes/funnels within paired testis sacs pendant or protuberant from 9/10 and filled with white coagulum; iridescent tinges on the sperm funnels leading, via long convoluted vasa deferentia (sperm ducts), to capsular prostates on the penial chambers.

Ovaries: In 11 possibly in ovisacs formed by septa; morphology not distinct: flimsy, horseshoe-shaped sacs seen in non-gravid specimens in 11 and 12, the first pair may contain ovaries (attached to 10/11 near penial chamber?), the second pair forming the ovisacs. In gravid specimens these paired ovisacs, extending from segment 11 to 16 at maximum distension, are packed with large yolky ova that distend and transverse septa and are easily detached during dissection.

Prostates: Much reduced as small glands attached to each penial chamber.

Spermathecae: Originating at 7/8 each with a simple spherical atrium (opening) and a long, thin duct that reaches back through segment 8 to a spherical ampulla that is attached to posterior of septum 7/8. [Previously I mistakenly had the ampulla attached to septum 8/9]. Adiverticulate but a small, digitiform appendage noted on one ampulla in one Samford specimen was perhaps a rudimentary diverticulum (cf. accessory gland noted in segment 7 in some other species – see Blakemore & Kupriayanova, 2010).

Gut contents: Fine soil and occasional quartz grits (geophagous?).

Cocoons: Spherical with a diameter of about 2 mm filled with numerous yolky eggs (see Figs. 1.4-1.6 from a Samford specimen).

Ecological Notes: Found in only two locations on a farm at Samford from well-drained sandy-loams, riddled with fine burrows and mottled in the top 10 cm by the worms' reworkings. Fine granular surface casts were also noted. Specimens were collected in association with similarly small *Amynthas minimus* and other species, but in one area the populations appeared pure and a count equivalent to 1,350 m^{-2} was recorded (Blakemore, 1994a). Following rain in April, 1992 this species was particularly active in the surface soils where many immature, mature (some specimens found in amphimixis – Fig. 1.2) as well as numerous cocoons were found (Fig. 1.1).

Cocoons were filled with numerous yolky cells (as seen in gravid specimens), and although all may be potential ova, only one or two juveniles were observed to hatch.

A five-fold increase in numbers was observed in culture after 10 months (Blakemore, 1994a).

In a series of glasshouse and field experiments, selectively introducing a variety of species, significantly increased plant yields of between 40-80% were recorded for

combinations using *D. barwelli* in both clay and sandy soils (Blakemore, 1994a; 1997).

Remarks: *Drawida barwelli* (Beddard, 1886) was regarded as *species dubius* by Gates (1965: 87; 1972: 244) because of "*omissions, errors, miscorrections and mislabelled or incorrectly drawn figures*" [as with many other valid species!], however, Easton (1984: 112) re-described the species from new material after finding that the British Museum type series, he thought comprised two different species, produced no useful data.

Easton (1984) placed *D. bahamensis* (Beddard, 1893) in the synonymy of *D. barwelli*, based on a composite description of the latter species derived from Beddard's original works and his own redescription, as he supposed the differences were confined only to: (a) a doubtful report of dorsal pores for *D. barwelli*, (b) supposed commencement of nephropores from segment 6 (cf. from segment 3), and (c) some variation in gizzard details which thus appear acceptable intraspecific variation within this taxon.

The Qld specimens examined here agree tolerably with Easton's re-characterisation [ignoring the two dubious Fiji specimens that Easton (1984) stated were larger than his others from the Pacific and that lacked atria and long ducts on the spermathecae (see Easton, 1984: fig. 1h)]. They also comply almost exactly with Beddard's original and with the descriptions by Gates (1965) of *D. bahamensis*, thus they are assigned to its senior synonym *D. barwelli* as per Easton (1984). In Gates' (1965) account these two species were separated mainly on the vasa deferentia being shorter in *D. barwelli* than in *D. bahamensis*, although Beddard (1893: 693) himself thought this difference "*is merely one of maturity of the various individuals*". Gates' spermathecal 'diverticulum' for *D. bahamensis* is probably an aberration (cf. Beddard, 1893: fig. 2). Several published descriptions may similarly refer to ontological development within a species, especially whether specimens were in their reproductive stages or not. Gates (1965: 93) says: "D. parva *(Bourne, 1894) in its supposed Indian homeland is not adequately distinguished from* D. barwelli *and what* D. "parvus*" Michaelsen, 1901 [1910?], from Aru Island may have been cannot be decided from such observations as were published*".

Another species very similar to, if not synonymous with, *Drawida barwelli* is *D. beddardii* (Rosa, 1890) of unknown type locality in Burma as redescribed by Gates (1972: 246) for Myanmar specimens that he placed in an informal "*beddardi*" species group (comprising 'adiverticulate' *D. constricta*, *D. delicata*, *D. rara* and *D. spissata*) all members of which may approach *D. barwelli* interspecificity in their variations. Several

of these names are described by Gates (1929) with the types placed in London as well as USNM.

The synonymy of *Drawida beddardii* by Gates (1972: 246) included *D. barwelli hehoensis* + *D.* "*fluvaitilis*" Stephenson, 1924 and *D. tecta* Gates, 1926, but he appears to have rejected the placement by both Beddard (1895: 200) and Michaelsen (1900: 116) of *D. beddardii* in the synonymy of prior *D. barwelli*. Michaelsen's (1900) synopses have spermathecal pores in c lines (*barwelli* + *beddardii*), or between b and c (*bahamensis*) as found in the specimens here, rather than at c or in cd lines as claimed by Gates and Easton (for *barwelli* and/or *bahamensis*). Perhaps the only distinguishing characters of *D. parva* are its spermathecal pores in cd lines and its 3-4 gizzards in 14-16,17 that now appear within bounds of *D. barwelli*.

Further synonyms may be *Drawida glabella* Chen, 1938 for reasons given in synonymy above, and the poorly-described *D. delicata* Gates, 1962; this latter because Gates (1962: 319-320) says it "*is distinguished from* beddardi *by the greater length of the male deferent ducts, by absence of parietal invaginations at ectal ends of male deferent apparatus or, if male porophores are everted chambers, by absence therein of protrusible tubular penes*" even though he precedes this with there being "*A filament at distal end of each male porophore...*" which sounds like penes and, if so would appear to qualify as *D. barwelli* as described herein.

The full relationship of all these synonymous taxa thus requires further resolution based on examination of types (where available) or new material, and DNA analysis…

The unresolved inventory of Reynolds & Cook (1976) makes these listings [with my comments in square braces]:-

bahamensis, *Moniligaster* Bedd., 1893: 690. *Typus amissus* (i.e., missing) [in *barwelli*].

barwelli, *Moniligaster* Bedd., 1886: 94. Types: BMNH 1904:10:5:522-3, 582. [This listing from Reynolds & Cook (1976: 76) appears to have been miscited or was confused by Easton (1984: 112) who states "*examination of the specimen (BMNH: 1904:10.5.2-3), and the associated slide of the body wall, produced no useful data. The specimen is a posterior fragment about 66 mm long. As this is considerably larger than the dimensions provided by Beddard, it is doubtful whether this individual belongs to the type series*.". Here I can only assume that Easton has inspected the type(s) as listed, and found them to be inadequate].

beddardi, *Benhamia* Mich., 1890: 3. *Typus amissus* (missing). [This entry a mistake for

Horst's species *Dichogaster beddardi*].

beddardi, *Moniligaster* Gates, 1940: 496. *Typus amissus* (missing) [= *M. cernosvitovi*].

beddardii, *Moniligaster* Rosa, 1890: 379. *Typus amissus* (missing). [A separate taxon].

delicata, Drawida Gates, 1962: 319. *Typus perditus* (missing).

hehoensis var. *Drawida barwelli* Stephenson, 1924: 324. Types BMNH 1925:12:34 and ZSIC Calcutta 1107. [Placed in synonymy of *beddardii* by Gates, 1972].

impertusa var. *Drawida barwelli* Stephenson, 1920: 200. Types ZSIC Calcutta 301, BMNH 1925:5:12:77. [Now elevated to species level].

japonicus, *Moniligaster* Michaelsen, 1892: 232. Types: Hamburg Museum 403. [See my notes below about the types of this taxon].

parva, *Moniligaster* Bourne, 1894: 371. Types unknown.

tecta, *Drawida* Gates, 1926: 148. Types US Nat. Mus. 19660, BMNH 1926:6:5:10-1. [This latter taxon was placed in synonymy of *beddardii* by (Gates, 1972)].

A review of *Drawida barwelli* by Easton (1984) excluded both *D. beddardii* (Rosa, 1890) and *D. parva* (Bourne, 1894) from its synonymy, but included *D. bahamensis* (Beddard, 1893) and "*D. japonica bahamensis* (Beddard, 1893)" since Michaelsen (1910) had revised his earlier description of *D. japonica* (Michaelsen, 1892) and redefined *D. bahamensis* (Beddard, 1893) as a subordinate 'variety' of *D. japonica*. If the variations within the other *D. japonica* subspecies are eventually determined to lie within the scope of *D. barwelli*, this would increase the distributional range of *D. barwelli* to include parts of China (and Japan). Re-inclusion of *D. beddardii* would further encompass Myanmar (and Thailand?); these last reports from Gates (1972: 246) who enigmatically gives a location for *D. beddardii* as "*(Chiengmai, Thailand?)*" from whence he also described a single dubious specimen of *D. vulgaris* Gates, 1930: 296 in his earlier "*Thai Earthworms*" paper (Gates, 1939: 73).

Small, pale *D. parva* (Bourne, 1894: 371, fig. 11) from Ootacamund may be synonymous with *D. barwelli* as it is described as 75 x 4.25 mm with male pores protruding as papillae and gizzards in 14-16,17.

Other similar taxa are *Drawida impertusa*, *D. japonica, D. nepalensis* and *D. ramnadana* as briefly described below to compare with this *D. barwelli* synopsis – any one of these are potential synonym candidates after DNA analysis (of type-specimens).

Drawida bournei (Michaelsen, 1897)

Moniligaster sp. Bourne, 1894: 375, pl xxiii, fig. 14.

Moniligaster bournei Michaelsen, 1897: 167; 1898: 144. [From Kandy. Berlin ZMB-7382].

Moniligaster pauli Michaelsen, 1897: 171. [From Trincomali. Types ?].

Drawida bournei: Michaelsen, 1900: 116; 1909.

Drawida pellucida bournei : Michaelsen, 1910: 50 (syn. *pauli*); Stephenson, 1923: 150 (syn. *pauli*).

Drawida bournei : Gates, 1943: 88.

Distribution: Sri Lanka (Vakvalla, Bentota, Kaniya, Kandy, Colombo, Trincomali).

Description: Body length 55-142 mm, width 2-4 mm. Segments 144-191. Body a blue-grey colour, more violet in life. Prolobous. Setae close aa=bc. Nephropores in cd. Dorsal pores absent. Clitellum annular 10-13. Spermathecal pores in 7/8 in c-lines. Male pores in 10/11 in b-lines. Female pore in 11/12 in b-lines. Genital markings absent but (*pauli*) thinning of clitellum allows grooves to form around the male pores. Septa 5/6-8/9 thick. Gizzards vary in some of 13-15 from five in 14-18 or perhaps four in 15-18 to three (in *pauli*) in 13-15. Prostates round and smooth on long coiled vasa deferentia (Gates). Ovisacs extend to 15. Spermathecal duct long, atrium absent.

Habitat: Probably found in Royal Botanical Gardens Peradeniya, Kandy, from Museum Gardens Colombo and in plant roots in damp ground near outflow of a hot spring (in Kaniya).

Remarks: Not peregrine but here included as it was thought similar to *D. barwelli* and *D. impertusa* by Stephenson (1920) and it further demonstrates variation in gizzards in *Drawida*.

Drawida ghilarovi Gates, 1969

Drawida ghilarovi Gates, 1969: 674. [Types in Moscow: 37-38].

Drawida ghilarovi : Ganin, 2013.

Distribution: Siberia in South Primorye and Khabarovsk neighborhood. Described from the southern slopes and spurs of the Sikhote-Alin Mountains, near Ussuriysk and in the Black Mountains. Its description by Ganin (2013) appears to show several distinct morphs with incursion into China and the border with North Korea. Recent molecular work also supports its status as a species-complex.

Description: [From Russian Red Data Book Anon. – http://hunt.rin.ru/html/article2319-1.html]: Body a greenish or dark bluish colour. Length 100-140 mm, width 6 mm. Segments from 170 -210. Lumbricine. Clitellum ring-shaped 9-15. Male pores in 10/11 medio-lateral. Female pores in 11/12. Gizzards four of (segments?).

Habitat: Inhabits oak and cedar-deciduous forest and peatland, common to a height of 600 m. In the Sikhote-Alin mountains has also been observed in broad-fir forest at an altitude of 800 m. In the valleys of mountain rivers it is less common.

Drawida hodgarti (Stephenson, 1917)

Fig. ex Stephenson, 1923: fig. 49 of *D. hodgarti* prostate ex Stephenson, 1917, fig. 2

Drawida hodgarti Stephenson, 1917: 366, fig. 2. [From Rangamati, Chittagong Hill Tracts, Bengal (now SE Bangladesh). Types (juveniles, three of) in Indian Museum (ZSIC 70/1) and British Museum (1925:5:12:121)]; Stephenson, 1923: 140, fig. 49; Gates, 1934: 237-238 (?syns. *affinis, papillifer*).

Drawida affinis Stephenson, 1917: 368; 1923: 132. [From Rangamati, Chittagong Hill Tracts, Bengal. Type (immature) in Indian Museum (131/1)]; Stephenson, 1923: 132; Gates, 1934: 234.

Drawida papillifer Stephenson, 1917: 370. [From Rangamati, Chittagong Hill Tracts, Bengal. "*Holotype*" (Gates, 1934: 247) in Indian Museum (83/1 a single mature)]; Stephenson, 1923: 148; Gates, 1934: 245-247 (syn. *rosea, ancisa* but no mention of *peguana*).

Drawida rosea Stephenson, 1922: 430. [From Under stones and in muddy pools around Dak Bungalow, Cherrapunji, Assam, India. "*Holotype*" (Gates, 1934: 247) in Indian Museum (681/1 a single mature)]. Stephenson, 1923: 155.

[?*Drawida peguana* Gates, 1925: 316. From Rangoon, Myanmar. "*Paratypes*" in British and US Natl. Museums – probably a junior synonym and, if so, **syn. nov.**].

Drawida ancisa Gates, 1933: 421. [From Sandoway, Bay of Bengal, Myanmar. Types missing].

Drawida papillifer papillifer : Gates, 1962: 340 (no synonyms!); 1972: 258 (syn. *affinis, hodgarti, rosea, ancisa*). ?**Syn. nov. NOTE: Gates (1972: 258) seemingly ignored page priority in elevating *papillifer* as nominal sub-species over**

***hodgarti* and *affinis*; it is doubtful that 55 years after the naming he was acting as ICZN's 'First reviser' to fix priority of these names, so Gates' priority can probably be reversed (or perhaps ICZN needs a more precise page priority definition?).**

Distribution: Widespread in Myanmar, and Bengal, Western India/Bangladesh.

Description: (from Stephenson, Gates, etc.). Length 37-125 mm by 3-5 mm. Segments 115-170. Colour dorsally and laterally – bluish grey, otherwise yellowish grey; clitellum red or whitish. Prostomium prolobous. Setae minute and closely paired. Nephropores near c or d. Clitellum annular 10-13. Male pores in 10 at or just lateral of b; spermathecal pores in 7/8 at or slightly median to c. Genital markings small paired or single in 7-8 and 10-11 near spermathecal and male pores. [These irregular markings may also be parasitic artefacts as suggested for *D. japonica* by RJB pers. obs.].

Septa 5/6-8/9,9/10 thickened. Gizzards in some of 13-20 (two to four of). Testis sacs intraseptal in 9/10. Prostates shortly tubular and coiled. Ovarian chamber perhaps absent, ovisacs extend back through several segments. Spermathcal ampulla in 7 large, pear-shaped; atrium a small, simple sac, thickly pear-shaped; spermathecal duct opens into basal part of atrial chamber. Nephridia present in 10.

Remarks: Stated to be related to *D. jalpaigurensis* Stephenson, 1916: 307 and to *D. travancorensis* Michaelsen, 1910: 46. Gates (1972: 257-258) ignored page priority when he elevated *D. papillifer* to nominal sub-species status over both *hodgarti* and *affinis* that have successive priority. A sympatric species is *D. rangamatiana* Stephenson, 1917: 369 from Bangladesh. Gates (1972) also had a subspecies as *D. papillifer peguana* although there is very little to separate it from the nominal sub-species, and that I provisionally restore to specific status herein (below) only to show what slight characters it may add to the current diagnosis, in actuality it too is most likely a junior synonym of *D. hodgardi*.

Drawida impertusa Stephenson, 1920

Drawida barwelli var. *impertusus* (sic) Stephenson, 1920: 200. [From Bombay. Types ZSIC Calcutta 301, BMNH 1925:5:12:77].

Drawisa barwelli var. *impertusa* : Stephenson, 1923: 134; 1930.

?*Drawida* sp. 2 Gates, 1943: 90. **Syn. nov**. [Juvenile specimens (3 of) from Manila almost identically described compared to current specimens from Lipa, PI].

Drawida impertusa : Gates, 1965: 87; 1982: 18; Blakemore, 2008, 2012.

Distribution: India, originally Bombay but now recognized more widely, eg. in Bangalore, Coimbatore and, significantly, reported from four sites in the Philippines, (?at Calayan Island far northern Philippines, possibly found along with 33 specimens of *D. bahamensis* from bank of small river, 23rd Oct., 1903 by McGregor of US Natl. Mus. Division of "Marine Invertebrates" Number 28710, or at Manila and elsewhere) (Gates, 1965: 87; 1982: 18). Bombay type-locality is from Victoria Gardens, also under a tree near a fort, high up on a hill, in a rotten tree and on the sea-shore; collected 30-vi-1917 by B. Prashad. Found by RJB at two sites in Philippines in 2013-14, both in rice paddy, at Lipa City, Batangas Luzon and Victorias on Negros, i.e., widespread on those islands.

Description: (From Stephenson, 1920; 1923). Size 45-48 mm (or to 75 mm Gates, 1943) by 2.5-3.5 mm. Segments, 130-132. Colour a blotchy olive, darker dorsally with still darker mid-D line, or unigmented (Gates, 1943). Prostomium prolobous. Dorsal pores absent, indicated in some specimens as small pale dots, but no perforations. Setae aa less than bc except at hind end [Gates' (1943: 90) specimens often lack anterior setae to segment 10, thus similar to *D. zhangetalia*??]. Nephropores in row below level of c lines. Male pores in 10/11 in mid-bc; bounded fore and aft by prominent lips; with a pair of indefinite but fairly large whitish papillae in segment in front of the male pores on 10 [those described by Gates, 1943 from Manila nearly reach from 9/10 to 10/11 and are elliptical, plus male field is depressed anterior and posterior to the male pore just as seen in current Lipa specimens]. Spermathecal pores in 7/8 below c lines. Female pores in 11/12 in b lines. Clitellum 10-13.

Gizzards typically four of in 14-17 or perhaps five of in 13,14-17 (or sometimes three?) of [Gates, 1943 has 12-14, 14-17 and 15-17 in his three Manila specimens]. Prostates flat, sessile, almost circular and "furry" glandular (cf. pear-shaped in *D. barwelli*). [Vas deferens loops to side of prostate and there are no spermathecal atria - Gates, 1943]. Ovarian chamber present, annular in 11, ovisacs present, extending back to 13,14,15. Otherwise as *D. barwelli* according to Stephenson (1920).

Remarks: Similar to Stephenson's concept of *D. barwelli* but with a pair of fairly large whitish papillae on the segment in front of the male pores in 10, and gizzards in 14-17 and, most distinctively, lack of dorsal pores unlike *D. barwelli* proper. In fact Stephenson said that the specific name "*impertusa*" alluded to this lack of pores. It is also similar somewhat to *D. bournei* (Michaelsen, 1897: 167) that Stephenson (1920: 202) says Michaelsen thought was itself a variety of *D. pellucida* (Bourne, 1894: 13);

but they are easily separable on the form of the prostates. The prostates are flat, sessile, almost circular and "furry" in *D. impertusa* cf. pear-shaped in *D. barwelli* and "*longitudinally ellipsoid body sessile on the parietes*" (Gates, 1943) in *D. bournei*.

Drawida japonica japonica (Michaelsen, 1892)

Fig. 3.1 from Stephenson (1923: fig. 52 seemingly mislabeling 'marking' on 10 as male pore); Fig. 3.2 from Chen (1959?: fig. 22); Fig. 3.3 from (Ohfuchi, 1965? Taken from Chen: #1 external, #2 internal, #3 a spermatheca. Note: Ohfuchi's #2 has miscounted the internal segments – a quite common mistake – cf. Chen's original); Fig. 3.3 from Kobayashi (1938: fig. 1 of a spermatheca being almost exactly similar to current sketch); Fig. 3.5 Shiga specimen (LBM1380000085 that provided DNA sample for Genbank data, RJB original); Fig. 3.6 Copy of the label for Hamburg Syntype #403; Fig. 3.7 Berlin Syntype #2122 showing habitus at low scale, anterior, internally (with remnant lhs ampulla, rhs prostate and vesiculate nephridium in 12) and externally, and mid-body showing dorsal pores; plus an enlargement of genital field.

Moniligaster japonicus Michaelsen, 1892: 232-233. [From Japan. Syntype in Hamburg Museum: 403 (Reynolds & Cook, 1976), but originally stated by Michaelsen as in Zoological Museum, Berlin: Verm. 2122 and this syntype also listed by Hartwich & Kilias (1989: 268 as "*Japan; HILGENDORF leg.*" just after *Allolobophora japonica* (Verm. 2117). Both were inspected by Blakemore in Blakemore & Kupriyanova (2010: 9), they were collected by Herr Dr Franz Hilgendorf, the latter definitely at Enoshima on 29.III.1875 – thus this is possibly a type locality of the *D. japonica* syntype although my searches of the island have thus far proved fruitless for this species, yet other Berlin specimens from the Hilgendorf series were definitely not collected there (e.g. Michaelsen's record of *M. sieboldi* that must be from further south). Gates (1939: 411-413) did not mention #403 but he inspected three specimens from Hamburg labeled "*V 1194. Drawida japonicus Mich. f. Typ. Dr Chen F. Wu c. Dr Michaelsen a. Nanking, China*" and other materials none of which were types, saying (on page 413) that the original two types – described by Michaelsen as "*Diese Art ist durch ein geschlechtstreifes und*

ein unreifes Exemplar vertreten" – were sectioned and are no longer available for study. This is incorrect as #2122 is a dissected specimen 26mm long with the last 24 of its 95 segments regenerated that, although the internal organs are mostly removed, is nevertheless in good condition. Note the "*Typ.*" in the China label refers to *D. japonicus f. TYPica* not to a true type specimen].

[?*Moniligaster bahamensis* Beddard, 1893: 690, figs 1-5; Beddard, 1895: 202. Type locality Kew Gardens imported with plants from the Bahamas. Types unknown and this confirmed from personal enquiries to NHM, London. Included by Michaelsen (1910: 50) as a *D. japonica* subspecies, it is now held in *D. barwelli* synonymy].

Drawida japonica : Michaelsen, 1900: 115; 1910: 48; Stephenson, 1922: 119, figs. 1-6; Chen, 1933: 189, fig.?; Gates, 1935: 3 (maintaining *D. graham* and questioning Chen's '*D. japonica*'); Chen, 1936: 291 (syn. *grahami*); Kobayashi, 1937, 1938: 94, fig. 1; Gates, 1939: 411 (cf. *grahami*); Kobayashi, 1940: 263 (part. + *propatula*); 1941: 458, 515; Chen, 1959: 15, fig. 22; Ohfuchi, 1965: 546 (plus fig. apparently copied from Chen); Easton, 1981: 37 (part. excluding *grahami* and with China not included in distribution range); Blakemore, 2003; 2005/2007 (syn. *grahami* from China).

Drawida japonica typica: Michaelsen, 1910: 49; 1927: 85; Stephenson, 1917: 366, fig. 1; 1922: 126; 1923: 142, fig. 52 (part. syn. *bahamensis* and explaining Michaelsen's initial incomplete description).

Drawida japonicus typicus: Michaelsen, 1931: 7.

Drawida japonicus : Michaelsen, 1931: 523 (part. syn. *siemsseni* that is sometimes mispelt "siemmseni").

Drawida grahami Gates, 1935: 3; 1939: 408. [From Suifu, Szechuan (Sichuan). Type(s) USNM: 20093. Said to have more ventral spermathecal pores in mid-bc otherwise cf. *D. japonic*a; three gizzards in 12-14 (as in three of Gates' five subsequent *D. japonica* specimens); one of seven of Gates' types lacked 'genital markings'. NOTE: described in just a dozen lines on a dozen characters].

Drawida propatula Gates, 1935: 449. [From China. Types USNM 20179. Said by Kobayashi (1938: 94, 1940: 263) to be similar although Kobayashi (1940: 265) maintained them separately only on extents of the ovisacs]. Syn. nov.

Blakemore in Blakemore & Kupriyanova (2010: 9).

Drawida japonica japonica : Blakemore, 2005/2007 (syn. *grahami*); 2008; Blakemore *et al.*, 2010: 1; Blakemore & Kupriyanova, 2010: 8, figs. 3.1-3.7 (syn. *propatula*).

Note: ***Drawida calebi*** Gates, 1945: 211 from India is a similar species, and should probably be combined. Here is it briefly summarized including information from Julka (1976 Mitt. Zool. Mus. Berlin, 52(2): 322): Length 35-83 by 2-4.5 mm. Segments 115-170. Unpigmented. Dorsal line present but no dorsal pores. Spermathecal pores just median to c-lines. Male pores slits at 10/11 in mid-bc. Nephropores close to d lines. GMs small, unpaired and median or closely paired in aa, and widely paired in bc, presetal and postsetal variously in 7-13. Gizzards two or three or four of in some of 12-17 (as shown in a table). Vas deferens short, in a small column of loops in 9, straight in 10 and entering the prostate directly. Prostates are "not quite spheroidal", sessile, smooth. Short penis present internally. Ovaries in conjoined 10/11 and 11/12 with ovisacs to 20. Spermathecal ampulla is small, conical or nearly spheroidal on duct four to five mm long to apex of atrium that may have glands on its anterior wall like those associated with the GMs. From Jubbulpore, Madhya Pradesh (type locality) and Nowgong, Satna, Manikpur and Tanda Falls (Gates) also Jharkhand, Orissa, Uttar Pradesh and Karnataka districts found in forests, pastures, croplands and compost pits.

Material examined: Berlin Kat. Nr. 2122 ("*Drawida japonica* Syntype! Japan. Hilgendorf") a dissected specimen 26mm long with the last 24 of its 95 segments regenerated and probably Michaelsen's '25 *segmenten regeneriert Hinterende*'- RJB pers. obs. IV.2010 - that, although the internal organs are mostly removed, is nevertheless in good condition. Hamburg #403 syntype label states collected by Hilgendorf in Japan but is only a desiccated posterior portion (ca. 8mm and 25 segments comprising mostly intestinal soil). Five specimens, two from "*Aichi*" [kanji for the prefecture] (one with dorsal pores and GMs and one without either) plus three from fields at Nagura-shi near Nagoya, Aichi-ken (one with dorsal pores but no GMs, the other two without either) all stored in Hachioji collection (RJB inspected 20.IX.2002); Watarase one specimen without dorsal pores but with GMs in 9lhs posteriorly and 10rhs anteriorly, and male pores in 10/11 on eversible penes with gizzards in 12-14 (coll. IV.2003 by Dr Takafumi Kamitani of YNU and RJB inspected 9.IV.2004); one specimen collected from Kamakura Daibutsu shrine 13.VI.2004 by RJB

(identified tentatively); four specimens from rice fields in Hikone (collected 19.VI.2009 by RJB) – one dissected and figured plus host for mtDNA COI sample (GenBank GQ500902); plus three others, all lacking dorsal pores but having GMs as detailed below (these latter specimens' regos LBM 1380000085 2009-13-3).

Distribution: Japan, from around Tokyo to Nagasaki and the Ryukyus, southern China, Taiwan, Korea (including Quelpart/Jeju-do), and south-east Asia. Inclusion of *D. propatula* adds central and northeast China. Stephenson (1923: 143), Gates (1939: 413 six specimens also from Murree) and Paliwal & Julka (2005 - http://www.zoosprint.org) list it outside the normal *Drawida* domain from the western Himalayas, India; and it is reported (as "*Drawida japonica* Michaelsen, 1917") from the famous Punjab beer-district of Solan, Himachal Pradesh (Dhiman & Battish, 2005 - http://www.zoosprint.org/). [**Note:** Stephenson's (1923) description included *bahamensis* that is now included in *barwelli* as it typically lacks 'genital markings'; cf. Japanese *D. eda* specimens lacking markings that have a male pore on extractible penis rather than external and 'flap-like' and cf. Gate's (1982: 18) *D. bahamensis* held separately].

A recent and currently unconfirmed/unpublished report is from Kansas, USA by M. Callam (pers. comm. June, 2013 at SES meeting).

Original author's summary description [Michaelsen (1900: 115)]: "*1.* ***D. japonica*** *(Michlsn.) 1892 Moniligaster japonicus, Michaelsen in: Arch. Naturg., v. 581 p. 232. Grau. Kopflappen klein. Borsten eng gepaart, in ventralen und lateralen Paaren; Borstendistanz aa gleich bc. Vor den männlichnen Poren am 10. Segm. je 1 Pubertätsgrube. 2 grosse kugelige Muskelmagen im 12. und 13. Segm. Testikelblasen kugelig; Samenleiter eng gewunden; Prostaten dick schlauchförmig. Ovarien im 11. Eiersäcke dick schlauchförmig, unregelmässig verdict und gekrümmt, vom Dissep. 11/12 bis etwa in das 16 Segm. reichend. L. 28, D. 3 mm; Segmz. 95 (Hinterende regeneriert). Japan*".

[*Translation*: Gray. Prostomium small. Setae tightly coupled in ventral and lateral pairs; setae distance aa equal to bc. Before each male pore on 10 is a puberty pit (= genital papillae). Two large spherical gizzards in 12 and 13. Testes sacs spherical bubbles; vas deferens tightly wound; prostates thickly tubular. Ovaries in 11; ovisacs thickly tubular, irregularly thickened and curved; reaching from 11/12 to around 16. Length 28; width 3 mm; segments 95 (posterior regenerated). Japan.].

External characters: (synonyms above and pers. obs. of types and specimens)**:** Grey

when preserved (Michaelsen, Stephenson and pers. obs. Aichi or, Hikone specimens, reddy in field and pale bleached in alcohol?). Size ~32-130 mm by 2-4.5 mm although Chen (1933: 194, 1959: 15) says up to 200 mm in specimens that Gates (1935: 4) doubted were conspecific. Segments up to 142 [cf. 126-179 by Kobayashi 1938, 1940 (for *D. propatula*); 195 by Chen]. Prostomium small and seen with a characteristic ventral cleft in Aichi and Biwa specimens (pers. obs.). Dorsal pores intermittently present (RJB pers. obs. in some Aichi specimens where they were in 9/10 seen due to ejecta although possibly small in 8/9 too, thereafter intermittent and, although gaping when present, they cease before segment 45) or, more usually, absent. Setae small and closely paired (aa = bc). Nephropores seen in anterior in d lines or above in 3-8, thereafter in cd or c or ab lines on each side from 9; less obvious in posterior. Clitellum 9,10-13,½14. Spermathecal pores 7/8 in bc (but closer to c). Male pore superficial lateral of b on porophore on 10 [according to mistaking GMs for male pores by Stephenson (1923) and by Gates (1935)] or correctly in 10/11 [by Michaelsen (1892: 232; 1900: 115) who says they are clearly in 10/11 and overhanging segment 11 after a pair (or unilateral) markings in 10, this repeated by Gates, 1939] current specimens have male pores on such protruded 'flaps' overhanging 10/11 and just lateral to b lines (pers. obs. and from types as per Michaelsen and Kobayashi) or as eversible penes in the Watarase specimen that may thus be suspect]; Hikone specimens have ventral region of segments 10 and 11 flared around the male pores to present a flattened area. Female pores in 11/12 in b lines. 'Genital Markings' variously in 7-13 [e.g. Michaelsen has them in 10, Stephenson in 7-9 and 12, Easton in 7-9 and 12-13, Chen in 7-12, and Kobayashi in 7-13 and, for *grahami* and *calebi* they are stated to be in 7-13 thus this is accepted as the extent]; that said, however, it is possible they are all just parasitic artefacts (RJB pers. obs.) – and sometimes they are absent [e.g., Gates, Kobayashi (1938) and RJB pers. obs. of Aichi specimens (cf. *D. barwelli*)].

Internal anatomy: Septa 5/6-8/9 thickened; septum 10/11 weak and displaced to enclose ovaries and egg-sacs in 11. Hearts 6-9. Nephridia holoic and vesiculate (always?). Spermathecae with ampulla from septum 7/8, mostly pear-shaped or spherical but sometimes with elongate extension to duct that is convoluted to small atrium. Testis sacs spherical, bulging from 9/10, vasa deferentia tightly wound. Prostates described by Michaelsen (1900: 114) as thickly tubular and by Gates (1939: 410, 412) as round, sessile discs (*grahami*) or club-shaped and erect (*japonica*); here

described as 'blunt'. Ovaries in 11 with long ovisacs from 11/12 as far back as 16 [or 43 according to Gates (1935: 3) who, rather condescendingly, said that "*These appendices were overlooked by both Michaelsen and Stephenson*" but he failed to allow that extent is dependent on stage of maturity]. Gizzards usually two in 12-13 (Michaelsen, Stephenson and pers. obs.) or there may be three in 11-13 (Stephenson) or 12-14 (Chen, Kobayashi and seen in Watarase and Hikone specimens) or in some of 11,12-13,14 (Gates cf. *D. barwelli*); intestinal origin variously in 15-18 after gizzards. Corresponding to the external 'markings' are small, white spherical bodies that are buried in body wall and appear to duct to exterior – however, these may be parasitic artefacts of gregarine sporozoites as they are easily detached in their entirety (pers. obs.).

Species associations: Although Michaelsen (1892) recorded other specimens at the same time from Japan, obviously with nation-wide distribution, e.g. the lumbricids probably from the north and *Duplodicodrilus schmardae* and *M. sieboldi* from mid- or southern Japan: *Eisenia fetida* (Japan; No. 2121, Hilgendorf); *Aporrectodea trapezoides* (Japan; No. 2119, Hilgendorf); *Eisenia japonica* (Japan, Enosima; No. 2117, - Hilgendorf rp. 29,III,1875), *Drawida japonica* (Japan; No. 2122. Hilgendorf rp.); *Duplodicodrilus schmardae* (Japan; No. 2120. Hilgendorf rp.), *Metaphire sieboldi* (Japan; No. 2113. Langegg rp., Hilgendorfi leg.), and *Metaphire hilgendorfi* [Japan, Hakodate; No. 2123, Hilgendorf rp. (Typische Exempl. α und Exempl. γ und δ). Japan; No. 2114, Hilgendorf rp. (Exempl. ε). Japan, Yokohama; No. 2149, v. Martens rp. (Exempl. β)] plus *Amynthas corticis* [as *Perichaeta indica* Horst. (Japan; No. 2118. Hilgendorf. rp.) and probably as *Perichaeta divergens* (Japan; No. 2116. Hilgendorf rp. this Berlin type now lost according to Hartwich & Kilias, 1989)].

Ecological and Economic Importance: Apart from contributing to soil fertility and a basis for food-webs, as with all other earthworms, this species had been utilized as a bioindicator for soils in China (Fang *et al.*, 1999 - http://www.informaworld.com/smpp/content~content=a727073398&db=all), assuming their identification is correct.

Remarks: In summary, the problem of integrity of *Drawida japonica* is that is was soon confused with *D. bahamensis* and thus perhaps introduced new characteristics into the definition. Subsequently, *D. bahamensis* was either included in *D. japonica* or transferred as a junior synonym of *D. barwelli*. This is possibly indicative of entities such as *D. bahamensis* being intermediate between these two earlier described taxa, and

thus eroding validity of either. Moreover, the only substantial characters differentiating *D. japonica* from prior *D. barwelli* are the flap-like male poropores (cf. Watarase specimens), gizzards not extending as far as 15, and possibly the cleft prostomium? Markings vary and, on current interpretation so far, may actually be parasitic artefacts. Whether these are parasitic and as such are truly characteristic of *D. japonica* is currently uncertain. Kobayashi (1938: 94) remarks how similar Chinese *D. propatula* Gates, 1935 is, but which is supposedly larger and has longer egg-sacs although these features are not now of much significance, thus it is placeable in synonymy.

Michaelsen (1910: 48-52; 1931: 523) recorded subspecies for this taxon, ***Drawida japonica siemsseni*** (Michaelsen, 1910) from Fuchow, China that Michaelsen (1931b: 7) later said "*seems somewhat questionable*" and which Gates (1939: 414) redescribed from the Hamburg type [labeled as "V 6333 *Drawida japonicus* Mich. *f. siemsseni*. Tiensin, Futschau" that he said was inadequate as the internal organs had been removed in course of the original dissection and lost (Reynolds & Cook, 1976: 170 mistakenly list type as "*6233*") – this type specimen reinspected and sketched by RJB in 2010 and sampled for COI barcode]. It is clearly a separate species having 6 gizzards (cf. Gates, 1935: 3), as the type is 110 mm long with ~333 segments! The other was ***Drawida japonica bahamensis*** (Beddard, 1893), for which types are listed as missing in Reynolds & Cook (1976: 75) and this confirmed by BMNH curators [RJB pers. comm. 24.III.2010 although Coles (1981:302) yet lists them as in BMNH], which was subsequently placed, at least by Easton (1984: 112) and Blakemore (2002, 2008), in synonymy of *Drawida barwelli* (Beddard, 1886).

Other similar species are *Drawida minuta* (Bourne, 1887: 672) with male and spermathcal pores in ab and gizzard(s) in 12-14, and *Drawida willsi* Michaelsen, 1907 that differs, at least, by being a bluish grey or reddish grey colour and it may have an additional pair of rudimentary male pores in 9/10 corresponding to those in 10/11, as is more usual. A specimen of '*D. willsi*' that Michaelsen (1907 or 1909?) described from Western Himalayas, was thought by Stephenson (1923) to be *D. japonica*. Hence *D. willsi* is briefly described below.

Kobayashi (1940b) had proposed a dispersal of *D. japonica* from China to Japan, possibly via Taiwan and questioned the identification of some earlier records from outside the Japan/Korea area. Although, Gates (1972: 244) was of the opinion that this species came originally from the Indian Himalayas, from whence it was recorded by Stephenson (1923), and from Yunnan and Szechuan, Stephenson (1923:

143) had earlier said its occurence at Murree and probably Simla (by Michaelsen, 1909) in the western Himalayas was "*far from the proper* Drawida *region*". This domain he regarded as in southern India and the eastern Himalayas and so Stephenson (1923: 143) said *D. japonica* was thus "*a wanderer* [i.e., a peregrine] *of a pronounced type*". Easton (1981: 37) included only Japanese and Korean records in his distribution range for this taxon.

Identification confirmed and augmented from inspection of new Japanese material. Major differences from some earlier accounts (in synonymy above) are that GM markings may be present only in 10 (just ventral of c) as per Michaelsen's original account **or absent**; Stephenson (1923: 142) has them in "*vii-ix and xii*" and Kobayashi (1938: 95) from "*about a thousand specimens from about a hundred localities*" allows either in 7-13 **or totally absent**, while Easton gives them in 7-9, 12 and13 [actually Easton (1981) states "*vii-ix, occ. 12 & 13*" which may be a mistake for "vii-xi, *occ. 12 & 13*", or not] and, for *D. grahami* synonym, Gates (1939) has them in 7-13 **or absent** in at least one of his Suifu specimens. Present specimens either lack them entirely or have them unilaterally or paired on posterior or anterior of some of 7-9 and anteriorly in 10 or 13. It appears Stephenson (1923: 142, fig. 52) mistook the paired genital markings posteriorly in 10 for male pores that he himself (p 124) describes as intersegmental in 10/11. Moreover, in the present specimens, dorsal pores may be absent or intermittent: e.g., one Aichi specimen had them from 8/9/10 but thereafter, although gaping, they became intermittent and were not present after segment 45. Gates did not mention any dorsal pores.

In Blakemore *et al.* (2010), I noted that recent COI barcodes (by Huang *et* al. 2007 and Chang *et al.* 2008) from Chinese source material differed by ~17% from a Lake Biwa sample and conspecificity of these Chinese entities needs to be reexamined.

Resolution requires further checking of Japanese specimens against *D. japonica* (syn-)types in Hamburg (#403) and/or Berlin (#2122), and the Chinese specimens, at least those still available, require comparison with synonymic *Drawida grahami* Gates, 1935 types (Smithsonian #20093), also with types of erstwhile sub-species *Moniligaster bahamensis* Beddard, 1893 and *Drawida japonica siemsseni* (Michaelsen, 1910) (Hamburg #6233), plus its likely new synonym, *D. propatula* Gates, 1935: 449 from China. *Drawida nepalensis* (Michaelsen, 1907) with gizzards in 13-20 and *D. ramdadana* (Michaelsen, 1907), are also reminiscent taxa.

It may be noted that *Drawida gracilis*, *D. rangoonensis, D. rara* Gates, 1925, and *D. flexa* Gates, 1929, and other similar taxa from Myanmar appear to differ only in their 2-5 gizzards in 12-23 – see Gates (1962: 320-351); another potential synonym is *D. vulgaris* Gates, 1930 [that is probably a senior synonym of *D. bullata* Gates, 1933: 424 (with its synonym *D. fucosa* Gates, 1933: 439) – see Gates, 1962: 313].

Table 1 Variations in genital markings (GM) & dorsal pores (DP) in *D. japonica*

Contingencies Found	GM Present (but variable)	GM Absent
DP Present (intermittent)	Yes	No
DP Absent	No	Yes

Table 2 Characters of *D. japonica* found in Japan, cf. *D. barwelli*

Characters /Drawida* cf. *spp.	***barwelli* summary** as here	***japonica* summary** as here	***japonica*** Aichi spec A	***japonica*** Aichi spex B	***japonica*** Biwa spex	***japonica*** Watarase spec
Colour	pale/unpig.	grey/pale	?	?	Pink/pale	?
Size (mm)	30-65	28-130	50	30-40	50-70	55
"GMs"	**None**	**7-13 or none**	**9 & 10**	**None**	**8-10**	**9 & 10**
Dorsal pores	**Yes/No**	**Yes/No**	**No**	**Yes/No**	**No**	**No**
Form of MP	penis in pouch	flap or mound	flap or mound	?	flap or mound	penis in pouch
Gizzards	2-4	2-3	2	2	3	3
Gizzard Segs.	12,13-14,15(,16)	(11,)12-13,14	12-13	12-13	12-14	12-14

Spec. – specimen; Spex. – specimens; Segs. – segments.

Table 3 Key characters of prioritized *Drawida* listed in Japan modified from Easton (1981: tab. 1) cf. *D. barwelli* 'proper' (pers. obs.)

***Drawida* spp. / Character**	***barwelli* (Beddard, 1886)**	***japonica* (Michaesen, 1892)**	***nemora* Kobay., 1936**	***koreana* Kobay., 1938**	***keikiensis* Kobay., 1938**	***ofunato-ensis** O., 1938**	***taira-ensis* O., 1938**	***morioka-ensis* O., 1938**

Colour	Pale/unpig-mented	Grey/pale	**Dark bluish**	**Dark blue**	Yellow/grey	Dark yellow	Flesh red	Dark lead grey
Size (mm)	30-65	28-130(200)	65-185	63-100	40-54	**228-283**	59-92	65-100
"GM"s	**None**	7-13 **I**	6-13 (**I**)	7-12 **I**	**None**	7-13	8 **I**	**None**
DPs	Yes/No	Yes/No	No	No	No	No	?	?
Gland in 7	No	No	**No/Yes**	No	**Yes**	No	**Yes**	No
Form of Male Pores	Penis in pouch	**Flap or stubby porophore in 10**	Penis in small pouch	**Flap or penis-like porophore in 10**	Penis in pouch	Penis in pouch	Penis in pouch	Penis in pouch
Gizzards	**2-4**	**2-3**	**3-5**	**2-3**	**3-4**	4+ (?)	4	**2-3**
Gizzard Segments	12,13-14,15(,16)	(11,)12-13,14	12,13-15,16	12-13,14	12,13-15	12-15,16?	13-16?	10,11-12

Kobay. – Kobayashi; O. – Ohfuchi; GM – genital marks; I – irregular 'markings' that may be absent or artefactual due to paratitic infection. **Bold** options distinguish taxa. ? – data not provided, ambiguous/inconsistent by original author or from Easton's table. *Misspelt "*onfunatoensis*" by Easton (1981: 35). [Notes: *D. hattamimizu* is excluded as dealt with by Blakemore *et al.* (2010) and it appears to have true, symmetrical and regular, GMs rather than parasitic artefacts].

From the key character data in Table 3 above it appears that:

- *D. japonica* differs from *D. barwelli* mostly in the form of male pores.
- *D. koreana* differs from *D. japonica* mostly in its blue colour.
- *D. keikiensis* differs from *D. barwelli* by its glands in 7.
- *D. moriakaensis* differs from *D. japonica* mostly on forms of male pores.

The newly described species from Lake Biwa, *Drawida eda* Blakemore, 2010, differs by having eversible male pores on penes, five gizzards in 13-17, lacking both pigment and genital markings, and in having an accessory genital gland near spermathecal atria internally in 7. The same sort of gland is also reported for *D. nemora* (only in some specimens!), *D. keikiensis*, *D. tairaensis* and *D. jeholensis*. Chinese *Drawida jeholensis* Kobayashi, 1940 is unpigmented, has irregular markings in 7-11, male pores on poropore 'flaps' overhanging 10/11, and two or three gizzards in 11,12-13; thus, the only major differences from *D. japonica* is presence of penis rather than flap and of this accessory gland in 7 near its spermathecal atria.

Atrial structure of poorly-known *Drawida jalpaigurensis* Stephenson, 1916: 306, which is otherwise quite similar to *D. japonica*, appears to be substantially

different to the accessory gland arrangement noted (see Stephenson, 1923: 141, fig. 51)

DNA barcoding, such as using mtDNA COI partial gene, ideally from primary types (Blakemore *et al.* 2010), offers a possible solution to taxonomic confusion within *Drawida* in Asia and further abroad, as has been initially attempted by Blakemore *et al.* (2010), Blakemore (2010, 2012), and herein (DNA data in GenBank).

Drawida koreana koreana Kobayashi, 1938

This species is fully described by the primary author in Blakemore *et al.* (2014). *D. koreana* is from Korea, China, Japan and, from DNA barcodes, its sub-spp are in Korea, Japan and on the Matsu Islands of Taiwan (see Blakemore *et al*. 2014: Appendix; Ref.).

Drawida longatria longatria Gates, 1925

Drawida longatria Gates, 1925; 1936: 309 (syn. *straeleni*); 1962: 326 (syn. *straeleni*). [From Myanmar. Types?].

Moniligaster straeleni Michaelsen, 1930: 4. [From Palembang, Sumatra. Types?].

Drawida longatria longatria : Gates, 1931; 1962: 328 (syn. *straeleni*); 1982: 18.

D. longatria longatria Gates, 1925 (syn. *straeleni* Michaelsen, 1930: 4).

Distribution: Rangoon, Myanmar, probably introduced to Palembang, Sumatra (Gates, 1962; 1965; 1972; 1985).

Diagnosis: Genital Markings in 7 just median to each spermathecal pore, and variously in 11-13; characteristically in 12 in bc. Described as highly variable in "*shape, size and direction of male porophores, in size, shape and location of genital markings..*".

Remarks: Subspecies are *D. longatria deminuta* Gates, 1930: 285; *nana* Gates, 1933: 461; *ordinata* Gares, 1930: 285; *planata* Gates, 1931: 344; *tortuosa* Gates, 1931: 344 and *verrucosa* Gates, 1931: 347. Probably few, if any, of these are sustainable names.

Drawida nemora Kobayashi, 1936

Drawida nemora Kobayashi, 1936: 141, text-fig. 1.1-8. [From Koryo "*(N.L. 37° 45')*" {sic}, Keiki-do, about 30 Km distant from Keijo, Korea collected from woodland about 300 m altitude by "*Mr Kiujiro Susaki, an assistant expert of the Forest*

Experimental Station, General Governemnt of Chosen" {sic} in April and July, 1934 . Types not known].

Drawida nemora : Kobayashi, 1938: 99-102; 1940: 272; 1941b: 263; Easton, 1981: 38, tab. 1; Blakemore, 2003, 2010.

Distribution: Central and North Korea, 'Manchuria', China and Honshu, Japan. E.g. from Koryo near Keijo, Korea (Kobayashi, 1936); with many other Korean records by Kobayashi (1938) some from Mt Kambo (at 2,000-2,500m) and Akashima in the far northeast of the peninsula "*found within wet roots of alpine plants such as* Pedicularis manshurica *Maximowicz in the former and under decayed leaved on granite on the latter*"; from several central "*Manchoukuo*" locations by Kobayashi (1940) and supposedly a Chubu-Chiho, Japan record by Kobayashi (1941). It is possibly introduced in some of these less remote locations, especiailly if associated with human activity.

External characters (from original descriptions in synonyms above and pers. obs.)**:** Dorsally a dark blue often with a purplish or yellowish tinge, less distinct ventrally and clitellar segments yellowish grey in life; when preserved a uniform yellow colour with faintly pink clitellum. Size 65-185 mm by up to 6.5 mm. Segments ca. 162-247. First two segments almost continuous (pers. obs.). Prostomium prolobous with ventral cleft. Dorsal pores absent. Setae small and closely paired (ab = cd). Nephropores seen in anterior in d lines in some segments. Clitellum mostly saddle-shaped in 9,10-13,14 (Kobayashi) or 9-15 (pers. obs.). Spermathecal pores 7/8 small pores in cd lines in transverse slits. Male pore secondarily superficial in 10/11 approximately in mid-bc in transverse slits that in some specimens are extruded slightly; primary pores shown by Kobayashi (1936: fig. 1.4) to be on small conical penes. Female pores paired slits in on anteror of 12 near 11/12 approximately in b lines. 'Genital Markings' reported by Kobayashi (1936) variously in 6-13 venrally detectable either externally or internally, or absent; actually these are probably parasitic artefacts (pers. obs. and see Blakemore *et al.*, 2010, Kinki I paper).

Internal anatomy: Septa 5/6-8/9 thickened; septa 9/10 and 10/11 fused dorsally to enclose ovaries and egg-sacs in 11. Pharyngeal glands in 3-4. Hearts 6-9 with single dorsal blood vessel. Nephridia holoic and vesiculate (absent from first and last segmens and from segment 12) with bladders elongate. Spermathecae with ampulla venral on septum 7/8, spherical to convoluted duct that exits to body wall without atrium nor accessory gland in 7/8 (Kobayashi, 1936: figs. 1.7-8), or (Kobayashi, 1938: 100) sometimes allows papillae just laterally to the spermathecal pores and "*accessory*

glands were found internally". Testis sacs spherical, intrasegmentally bulging to both sides on 9/10 with vasa deferentia slightly wound and entering body wall under prostates. Prostates described definitively as "*thick oval or circular disc, sessile on paietes*" mostly in 10 that exit to 10/11 via blunt conical penis. Ovarian chamber in 11 with long ovisacs from fused 10/11/12 as far back as 14. Gizzards usually four in 12-15, or sometimes five in 12-16 (weaker in 12?) or three in 13-15 (i.e. three to five of in 12,13-15,16). Corresponding to the external 'markings' are small, white spherical bodies that are buried in body wall and appear to duct to exterior – however, these may be parasitic artefacts of gregarine sporozoites (pers. obs.).

Species assocations: Kobayashi (1936: 137, 146) said this species was "*most abundant, followed by* Pheretima hilgendorfi*, and the Lumbricid worms are small in number*" as he went on to describe 13 other *Pheretima* spp. and lumbricids in addition to *D. nemora* from the same collection. Most Korean localities were hilly and remote.

Remarks: Kobayashi (1938: 102) noted that in fully mature specimens the large genital organs may expand and intrude into adjacent segments.

Drawida nepalensis nepalensis Michaelsen, 1907

Fig. 1 from Pl. XIII Michaelsen, 1909

Drawida nepalensis Michaelsen, 1907: 146. [From Gowchar near Katmandu, Nepal. Types in Hamburg, 7140 – five aclitellate syntypes labelled "*Drawida nepalensis Michlsn. Hodgart Nepal*" according to Gates (1934: 243)]; Michaelsen, 1909: 147, pl XIII, fig. 1; 1910: 8; Stephenson, 1917: 372, fig. 4; 1922: 430; 1923: 146; Gates, 1934: 242 [syn. *burchardi, papillifer* (part.)]; 1962: 331 (syn. *burchardi, jalpaigurensis, troglodytes, cacharensis*); 1972: 256 (syn. *burchardi, troglodytes, cacharensis*), 1972: 257 (syn. *abscisa*); 1982: 18.

Drawida burchardi Michaelsen, 1903: 7. [From Sumatra (LomgeiLalah, Indragiri) and Stephenson (1923: 134) and Gates (1934: 243 – see Gates, 1962: 331; 1972) from Mt Harriet, Andamans. Single type from Sumatra in Hamburg # 5781 said by Gates (1934: 243) to now be only a posterior portion and thus he has it *sp.*

dub.]. Note: sometimes misdated as 1902 or as "*Michaelsen, 1909: 149*" which is a later citation. It seems that only the gizzard location in 15-17 separates this taxon from *D. barwelli*. NOTE PRIORITY! It may supercede *D. nepalensis*.

?*Drawida jalpaigurensis* Stephenson, 1916: 307; Plate XXX figs. 4, 5. [From mud at Jalpaiguri, at base of the eastern Himalayas. Type in Indian Museum].

Drawida troglodytes Stephenson, 1924: 129. [From 2,000 ft. at entrance, Siju Cave, Garo Hills, Assam. Type in Indian Museum W 1150/1 inspected by Gates (1934: 253)].

Drawida cacharensis Stephenson, 1926: 251. [From Katlichers, Assam, India. Types in Indian Museum].

Drawida abscisa Gates, 1931: 336 [non *ancisa* Gates, 1933]; Gates 1962: 336-339. [From Sandoway, Bay of Bengal, Myanmar. Types Indian Museum 3068].

Distribution: Katmandu (Nepal), India, Pakistan (e.g. Lahore), Bangladesh, Myanma, China (Yunnan), Andaman Islands, Java (Buitenzorg) and Sumatra (*burchardi*). From sea level to >4,500 ft (1,500m). Gates thought that the worm in Rangoon, Bassein and Sandoway were introduced from a source possibly in the region of Myitkyina, Myanmar, or more likely from an original Himalayan homeland and that the species was partly spread by man.

Habitats: Gates (1972: 257) lists "*Soil. Earth at base of bamboo clumps. Mud under water cress*" - these latter two locations could easily explain its spread via human acts. Harudia *et al*. (2001) call the *burchardi* synonym "*anecic*", but this must be queried.

Description: (from Michaelsen, Stephenson, Gates). Colour yellowish grey, non-pigmented. Length 50-128 mm by 1.4-5 mm. Segments, 149-180. Prostomium prolobous. Setae closely paired. Dorsal pores absent. Nephropores in cd. Clitellum annular 10-13. Male pores on prominent eye-shaped papillae between b and c. Female pores in ab. Spermathecal pores just ventral of c or in cd. Genital markings sometimes paired anteriorly in bc (in *jalpaigurensis*) on 7 or mid-ventral cushions on 7 and 8, or absent. [Gates (1962: 339, tab. 8) has genital markings variously cited in his *D. nepalensis abscissa* variety – these marking variation also suggest parasitic artefact, as for *D. japonica* as noted herein].

Septa 5/6-8/9 strong. Gizzards in 13,14,15-17,18,19,20 (three or four, or more, of – see Gates 1962: 338-9, tabs 7,9 – but one or more of which may not be in consecutive segments). Testis sacs intraseptal in 9/10. Prostates long U-shaped loop. Ovarian chamber present, ovisacs extend back through several segments. Spermathcal

ampulla irregularly pear-shaped; atrium large sac, spermathcal duct continues as an undullating neck to opening. Stephenson (1916) describes an independent sac on each side that is associated with but separate from the atrial swelling which he says resembles that found in *D. travancorensis* that he then distinguishes on (minor) points of "*setal relations, the characters of the male apertures, the situation of the spermathecal apertures, and the relation of the testis-sac to the septum*".

Remarks: Stephenson (1923: 147) said: "*Michaelsen suspects the identify of this form with* D. uniqua" this because Michaelsen compared *D. nepalensis* to prior "*? Drawida uniqua (BOURNE), MICHAELSEN, Oligocliaeta, in Tierreich, Lief. 10, p. 1 18*". Gates (1972: 257) thought it similar to *D. papillifer* (= *D. hodgarti*). Gates also noted 'head' regeneration back from 6/7. Personally, I think that *D. nepalensis* resembles *D. barwelli* for which several of these earlier authors were unfamiliar with due to the errors and omissions of its initial description(s). Thus, there is a chance that *D. nepalensis* is a junior synonym of *D. barwelli* (cf. description above).

A subspecies was ***Drawida nepalensis abscisa*** Gates, 1931: 336 from Myanmar with Indian Museum types (redescribed by Gates 1962: 336-339) that was unsupportable from the latter detailed description (that included note of removal of a rival Missionary by reporting him as a Communist Spy) thus it was synonymized by Gates (1972: 257).

These taxa urgently needs to be compared to the variability such as acceptable for *D. barwelli* and, now also, for *D. japonica* (RJB pers. obs.).

[***Drawida peguana*** Gates, 1925

Drawida peguana Gates, 1925: 316. [From Rangoon, Myanmar. "*Paratypes*" in British and US Natl. Museums].

Drawida papillifer peguana : Gates, 1962: 342; 1972: 258.

Distribution: widepread in Myanmar from sea level to ca. 4,000 ft.

Diagnosis: Aledged to differ from *D. hodgarti* by male pores at 10/11 as longitudinal or diagonal slits median to mid-bc. Size, 50-130 mm by 3-6 mm. Segments 168. Genital markings variable as noted by Gates (1962: 344 tab. 10) – these marking variation also suggest parasitic artefact, as for *D. japonica* as noted herein

Gizzards, two to five of in 12-19. Intestinal origin in 22. Sperm ducts very short almost straight in 10. Prostates long without glandular investment near body wall.

Remarks: Since these differences are only slight from its erstwhile nominal subspecies,

the current taxon most likely joins it in synonymy of *D. hodgarti* as noted above].

Drawida ramnadana (Michaelsen, 1907)

Drawida ramdadana Michaelsen, 1907: 145. [From Ramnad, Madura District of Tamil Nadu South India, on sandy coastal plains. Types in Hamburg and Calcutta]; Michaelsen, 1909: 146; Stephenson, 1923: 152.

Distribution: Ramnad, South India and reported from Bandung NW Java, Indonesia (Dec., 2005) http://digilib.bi.itb.ac.id/go.php?id=jbptitbbi-gdl-s2-1993-j0k0waluy0-661 from "*grass, shrubs, pine forest and natural forest biotopes at 700m - 1700m altitude".*

Description: (from Stephenson, 1923). Length 44-55 mm by 1-2 mm. Segments, 165. Colour dorsally and laterally – bluish grey, otherwise yellowish grey. Prostomium prolobous. Setae minute and closely paired. Nephropores in cd. Clitellum annular 10-13. Male and spermathecal pores in b.

Septa 5/6-8/9 thickened. Gizzards in 12-14 (three of). Testis sacs intraseptal in 9/10. Prostates shortly tubular. Ovarian chamber perhaps absent, ovisacs extend back through several segments. Spermathcal ampulla large, pear-shaped; atrium a small, simple sac, thickly pear-shaped; spermathcal duct opens into basal part of atrial chamber.

Remarks: "*Seems to be nearly allied to* D. japonicus" Stephenson (1923: 152).

Drawida willsi Michaelsen, 1907

Drawida willsi Michaelsen, 1907: 145. [From Bilaspur in Central Provinces, Deccan, Hyderabad]; Michaelsen, 1909: 143; Stephenson, 1923: 161; Gates, 1945: 214.

Distribution: From Bilaspur in Central Provinces, Hyderabad, Deccan (Michaelsen, Stephenson) and Jubbulpore, Satna, Rewa, Manikpur Junction (Gates). Its distribution is given as: "Jharkhand: Ranchi, Dhurwa, Morhabadi, Kantatoli, Harmu, Ramgarh, Khunti. Orissa; Madhya Pradesh; Andhra Pradesh; Uttar Pradesh."

Description: Length 55-60 mm by 2.5 mm. Segments, 155-160. Setae aa<bc. Colour variable, blueish grey or reddish grey. Prostomium prolobous. Setae minute and closely paired. Nephropores in cd. Clitellum annular 10-13. Male pores in b spherical equally in 10 and 11 with small conical porophore; spermathecal and female pores in ab . GMs (not mentioned by Michaelsen nor Stephenson) absent or in 9/10 in b-lines extending equally onto 9 and 10 in line with male pores (and Gates means in addition to occasional

extra male pores in 9/10 noted or mistanken for such by Michaelsen and Stepheson), these GMs have glands internally that are usually smaller than the prostates (Gates).

Septa 6/7-8/9 thickened. Gizzards in 14-15 (two of in 14-15 in Michaelsen and Stephenson) or two to four of in some of 12-16 (Gates). Testis sacs intraseptal in 9/10. Prostates shortly tubular or pear-shaped on rather short but looped vas deferens. Ovarian chamber perhaps absent, ovisacs extend back through several segments. Spermathcal ampulla ovoid; atrium largish simple sac, ovoid; long coiled spermathcal duct opens into ectal end of atrial chamber. (Translating from Michaelsen, 1907 - *Ampulla and a long, narrow, slightly coiling duct opens in the rear of the distal end of the atrium. The atrialsack is excessively large, ovate, nearly sessile, projecting into the 7th segment*.)

Note: Gates (1945: 214) remarks that the GMs in 9/10 always appear later than the male porophores and are smaller than the porophores.

Remarks: A dominant earthworm in Indian rice fields, also widely distributed as a vermicomposing species in India and often used for ecotoxicology studies. Dash (1999) reported the presence of cullulase, urease, invertase and protease in its gut. For *D. willsi*, "*The specimen referred to by Michaelsen as coming from the W. Himalayas was probably* D. japonica" – Stephenson (1923: 161).

Genus **Moniligaster** *Perrier*, 1872: 130

Type species: *Moniligaster deshayesi* Perrier, 1872 by original designation.

Moniligaster deshayesi Perrier, 1872: 130-141, figs. 77-84; re-decribed by Stephenson, 1923: 121 (cf. Beddard, 1895: 199).

Diganosis: Differing from *Drawida* by the definitive Y-shaped (or at least stalked) glands as shown in Perrier's fig. 79 where they are mistaken for anterior testis glands and in Benham's (1893) description of his *Moniligaster indicus* (= *Moniligaster indica*) that is stated by Bourne (1894: 366) to be a junior synonym of *M. robusta* Bourne, 1886/7. Bourne's (1894) original publication, with color ink figures, is here – Ref1 or figures here: Ref2, and text here: Ref3; it includes *Moniligaster grandis* the 'giant" worm from India that is now in *Drawida* along with several other of his taxa were subsequently transferred to *Drawid* (e.g. by Gates, 1943: 88).

Distribution: Several species from Tamil Nadu and India checklisted by Blakemore (2007) here and here {please note that mistyped "Perrier, 1972" is obviously a *lapsus*

pro “Perrier, 1872”}.

Note: ICZN (1999: Art. 30.1.2.) states a genus name ending in *–gaster* should be treated as feminine. However, this genus attracted many species names with endings that are masculine “*–us*” that, if not transferred, would need changing to feminine. Perrier (1872: 112) initiated “*le genre* ***Moniligaster***” but this is insufficient under the Code.

Family **Ocnerodrilidae** Beddard, 1891

Ocnerodrilidae Beddard, 1891: 581; (Michaelsen, 1900); Gates, 1942: 65; 1972: 267.

Type-species and type-genus: *Ocnerodrilus occidentalis* Eisen, 1878.

Diagnosis: Setae, eight per segment. Spermathecal, female pores (always paired?) and male pores in that antero-posterior order. Male pores on 17 or 18, rarely 19 or 20; prostatic pores 1-3 pairs between 16-21 or aborted. Clitellum, multilayered, including female (and male?) pore segments. Digestive system usually with one or two oesophaeal gizzards; a short oesophagus typically with calciferous glands or lateral "*ocnerodrile diverticula*" in 9 and/or 10 (or glands absent, e.g. in Malabariinae); intestinal origin in 12; intestinal gizzards and caeca absent. Spermathecae, in front of testis segments. Ovaries, in 13, fan-shaped and with several egg-strings. (Ovisacs?). Ova not yolky, but large. Seminal vesicles, trabeculate (i.e., composed of irregular outgrowths from septum). Prostates tubular. Nephridia holoic, avesiculate. Hearts, the last pair in 11 (rarely 12).

Distribution and diversity: Neotropical (original homeland? – see Christoffersen, 2008) and/or Ethiopian; plus (Malabariinae) in the Indian region. Currently about 200 taxa are described (data extrapolated from Csuzdi, 2003). Species small, often semi-aquatic or found in high moisture soils (e.g. paddy), parthenogenetic and widely distributed in tropics. Beddard (1892b, 1893a,b) (re)described seven new species imported to Kew Gardens in soil from the Caribbean/Africa (Sims & Gerard, 1999: 138), as noted below.

Remarks: The two sub-families are Ocnerodrilinae Beddard, 1891 and Malabariinae Gates, 1966. The Malabaraiinae lack extramural calciferous glands, while the Ocnerodilinae are generally characterized by these glands, more usually called 'Ocnerodrile Diverticula' as their function is not fully known.

Sub-family **Ocnerodrilinae** Beddard, 1891

Diagnosis (from Gates, 1972): Digestive system, with extramural calciferous glands (= ocnerodrile diverticula) in region of 9-10 (or intramural). Vascular system, with extra-oesophageal trunks that pass into the calciferous glands, branch therein, and after uniting posteriorly emerge to join the supra-oesophageal trunk; last hearts in 11.

Distribution: Africa, America in tropical and possibly also in adjacent subtropical regions. About 20 genera, several (smaller) species peregrine.

Sub-family **Malabariinae** Gates, 1966

Diagnosis (from Gates, 1972): Digestive system, without extramural calciferous glands. Vascular system, with extra-oesophageal trunks passing in region of 8-9 to eosophagus ventrally then continuous into 9-12; last hearts in 11. Spermathecae adiverticulate. Male pores acanthodriline only in *Thatonia* Gates, 1942: 101.

Distribution: India and perhaps Myanmar, three genera. *Malabaria* Stephenson , 1924: 356 with genotype *M. paludicola*) (syns. *Aphanascus* Stephenson, 1924: 360 with genotype *A. oryzivorus* ; *Filodrilus* Chen, 1938: 422 with genotype *F. levis* Chen 1938) [Gates (1942)] has *Malabaria levis* (Chen, 1928) found in China from an unknown homeland, appearing transported to Myanmar, Vietnam and Hainan. *Thatonia gracilis* Gates, 1942 is found in Myanmar, and *Thatonia exilis* Gates, 1945 [mispelt "*exilus*" by Reynolds & Cook (1976: 100)] is reported from India, Laos and Vietnam (Thai & Samphon, 1991; Thai, 2000). A third genus, *Deccania* Gates, 1949 with two gizzards in 6-7, is monotypic for *D. alba* Gates, 1949 from Jubbulpore, India.

Key to Ocnerodrilid Genera from Michaelsen (1900: 368) (now somewhat dated)

(Cf. Eisen, 1900: 110). PP = prostatic pores

1. Male pores in 18 ……2
   Male pores in 17 (or absent) ...……4
2. PP 2 pairs either side of male pores (by one segment length) .....*Eukerria*
   PP 2 or 3 pairs near the male pores (by less than one segment length) 3
3. Two gizzards in segments 7 & 8 ……..……..……*Nannodrilus*
   One gizzard, or none ……..……*Gordiodrilus*
4. Spermathecae with diverticula near exit ……..……*Pygmaeodrilus*
   Spermathecae without diverticula at exit (parthenogenetically degraded) ...5
5. Two gizzards in segments 6 & 7 ……..…….*Nematogenia*
   Gizzard absent ….*Ocnerodrilus* (then including *Ilyogenia* & *Phoenicodrilus*)

Key to Genera of Ocnerodrilidae with Peregrine Species

1. Oesophageal gizzards (i.e., before intestine) absent .....…..... 2
   Oesophageal gizzard(s) present (usually single in 7 in *Eukerria*) 4
2. Ocnerodrile diverticula paired in 9; male pores on 17 (or absent) 3
   This gland single, ventromedian in 9; male pores on 18 …….. *Gordiodrilus*

3. Spermathecal diverticula (and/or spermathecae) missing ……. *Ocnerodrilus*

Two or more spermathecal diverticula present ……..… *Pygmaeodrilus* Michaelsen, 1890 (type *P. quilimanensis* Michaelsen, 1890: 11) several semi-aquatic species apparently endemic to both Central/East Africa (Ref.) and Brazil (Ref).

Spermathecae 3 pairs and prostates 3 pairs (in 16,17 & 18/19) … *Diaphorodrilus doriae* Cognetti, 1910 monotypic from Fernando Po.

4. Two gizzards in 6-7 or 7-8 ……...…. 5

Single gizzard in 7 …… 6

5. Ocnerodriline diverticula paired in 9; gizzards in 6-7..... *Nematogenia*

This gland single, ventromedian in 9; gizzards in 7-8..... *Nannodrilus* [type *Nannodrilus africanus* Beddard, 1894: 388 from Lagos, Nigeria or "*Ober-Guinea*" in tropical West Africa (Michaelsen, 1900: 375). Gates (1942: 80-81) says "*To be included in* Nannodrilus *are:* africanus *Beddard 1894 (Lagos),* staudei *Michaelsen 1897* [sometime dated "1898"] *(Egypt), phreoryctes Michaelsen 1903* [sometimes spelt "phreorictes"] *(Cameroons),* schubotzi *Michaelsen 1915 (French Congo) and possibly* togoensis *Michaelsen 1913 (Togo), as well as another form hitherto unrecognized as specifically distinct* [viz. johneni *Michaelsen 1936 (Belgian Congo)*]. *The distribution may indicate an endemic area in Dahomey to French Congo, the Egyptian record a result of transportation*."]. *Nannodrilus staudei* Michaelsen, 1897: 31, an aquatic species from Ishmalia and Giza near Cairo (where the pyramids are), and Bedraschin, Egypt with waterplants in the Nile region that was also discovered in 1969 by S. Ghabbour from Ain Khosh, in the south of the Kharga Oasis in the western desert; thus it is possibly a widely dispersed native. [The species claimed from Kew Gardens by Sims & Gerard (1985, 1999: 139), is a mistake of *Nannodrilus africanus* Beddard, 1894: 388 from Lagos for *Ilyogenia africana* Beddard, 1892/3: 703 from Durban (Natal) – see *Ocnerodrilus* below].

6. Ocnerodrile diverticula absent ……... 7

Ocnerodrile diverticula present ……..… 9

7. Quadrithecal, spermathecal pores at 7/8/9 ……. *Thatonia* - endemic to north central part of Deccan, occurrence in Gangetic Valley likely due to fluvial transportation; a single species – *Thatonia gracilis* Gates, 1942, possibly imported to Myanmar (Gates, 1972: 267); species often in high moisture soils.

Bithecal, spermathecal pores at 8/9 ……..... 8

8. Calciferous glands present ..... *Thatonia exilis* Gates, 1945 originally

known only from 11 juveniles from Deccan, India now reported from Laos and Vietnam (Thai & Samphon, 1991; Thai, 2000).

Calciferous glands absent ..... *Malabaria*

9. Ocnerodrile diverticula paired in 9 ..... *Eukerria*

Ocnerodrile diverticula unpaired, ventral in 9 and 10 …….. *Curgiona* - monospecific *Curgia narayani* Michaelsen, 1921 from Coorg, Karnataka, South India presumably introduced from an African homeland (Gates, 1972: 268). [*Curgiona* Gates, 1941: 497 nom. nov. pro *Curgia* Michaelsen, 1921, (preocc. trichoperan *Curgia* et lepidopteran *Curgia* Walker, 1860, 1863)].

Genus ***Eukerria*** Michaelsen, 1935

Kerria Beddard, 1892: 355; Michaelsen, 1900: 369; Stephenson, 1930: 859.

Eukerria Michaelsen, 1935b: 102 nom. nov. pro *Kerria* (non *Kerria* Targioni-Tozzetti, 1884 Coccidae); Gates, 1972: 269.

Type-species: *Kerria halophila* Beddard, 1892, from South America in the upper reaches of the Pilcomayo River (that occupies Bolivia, Paraguay and Argentina) in exceedingly salty, bitter water.

Diagnosis: Lumbricine, setae closely paired. Prostatic pores two pairs, in 17 and 19, male pores in seminal grooves on 18. Spermathecal pores two pairs in 7/8/9. Gizzard in 7 (or absent?). Calciferous glands or diverticula, one pair in 9. Proandric (testes in 10). Holoic. Prostates tubular.

Distribution: South America; two species are circummundane: *E. kuekenthali* in Brazil, the Caribbean, Indian Ocean, and Indo-Asia regions, and *E. saltensis* in Chile, Mexico, Cuba, Argentina (etc.), Spain, Australia, USA, South Africa, New Caledonia, Myanmar and Japan (new record, RJB) and UK. *Eukerria rubra* (Friend, 1916) described from a lily tank in the Botanic Gardens, Oxford according to Sims & Gerard (1985: 138) is possibly an *Eukerria eiseniana* (Rosa, 1895) from S. America [syn. *hortensis* Stephenson, 1931: 314 from India (Ref.) but the spermathecae are dorsal in or above d]. Friend's Fig. 2 shows an oesophageal thickening of 8 (a rudimentary gizzard?), and spermathecae are described in 8 & 9 (cf. his fig 3 has them in 7 & 8). Two similar, if not synonymous, species described by Eisen (1893) from Baja California are *Eukerria mcdonaldi* that was subsequently found in Argentina, and *E. zonalis*. The genus is particularly species rich in and adjacent to Argentina (Blakemore, 2006; 2007;

Christoffersen, 2008).

Note: Genus *Kerriona* is separated mainly on the grounds that it is terrestrial.

Key to *Eukerri*a peregrines found outside of South or Central America

Spermathecal pores in 7/8/9 in setal ab lines ..... *E. kuekenthali* (Michaelsen, 1908)

Spermathecal pores 7/8/9 slightly median to setal c lines ... *E. saltensis* (Beddard, 1895)

Eukerria kuekenthali (Michaelsen, 1908) emend.

Kerria kükenthali Michaelsen, 1908: 24 [Type locality St Thomas, West Indies. Types in Berlin and Hamburg Museums, transferred to Wroclaw: 515 (syntype)].

Kerria selangorensis Stephenson, 1931: 279. [From Selangor, Kuala Lumpur. Types BMNH:1933.2.14.62-7]. [Miscited as "selangoriensis" in Reynolds & Cook (1976: 169)].

Eukerria peguana Gates, 1942 :67; 1954. [Type locality Rangoon. Types none].

Eukerria kükenthali: Gates, 1935: 94; Michaelsen, 1935b: 102 (syn. *selangorensis*).

Eukerria kukenthali (sic): Gates, 1972: 269 (syn. *peguana*).

Kerria kukanthali: lapsus by Reynolds & Cook (1989: 30) who also misdate Michaelsen, 1908 as "*Michaelsen, 1916*".

Eukerria kuekenthali : Blakemore, 2002 [emend. per ICZN (1999) but see note below].

Taxonomic Note: Spelling of the name *kükenthali* was emended to *kuekenthali* (under ICZN, 1999: Art. 32.5.2) by Blakemore (2002) although I since found that Reynolds & Cook (1992: 25) made the same emendment although under a different code (ICZN, 1985?); the name was previously spelt as "*kukenthali*".

(The following description is extracted from various authors in the synonymy above).

Diagnosis: *Eukerria* with spermathecal pores in 7/8/9 in setal ab lines. Nephridia possibly absent from anterior segments.

Distribution: Widespread; Myanmar, India (Julka, 1988: 40), Malaysia, Vietnam (Thai, 2000), Puerto Rico, St. Thomas, Belize, and Brazil - these latter reports may be closer to its original homeland in the warmer regions of South America. The Australian record is from Christmas Island south of Java (Michaelsen, 1935b; Gates, 1935).

Locality: Not found in current study.

Habitat: "*A semi-limnic, if not amphibious, perhaps also euryhaline, species*" (Michaelsen, 1935b: 102).

Registration No.: None.

Behaviour: ?

Length: 20-70 mm.

Width: Generally 1 mm.

Segments: 105-142.

Colour: Unpigmented.

Prostomium: "*prolobous?*".

First dorsal pore: None.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment from 2, setae ab absent on 17 and 19 may be absent; (ab=cd, aa=bc, dd=0.5U).

Nephropores: Inconspicuous.

Clitellum: Annular but may appear saddle-shaped, in 13-20.

Male pores: On 18 just lateral to setae b in seminal grooves prostatic pores in 17 and 19.

Female pores: Paired at anterior of 14 near setal b lines.

Spermathecal pores: In 7/8 and 8/9 in setal ab lines (cf. *E. saltensis* nearer c lines).

Genital markings: In (20 and) 21, transverse thickening extending to just lateral of setae b where there are small pores (internal tubular glands correspond to these pores).

Septa: 5/6-8/9 muscular.

Dorsal blood vessel: Single.

Hearts: 9-11.

Gizzard: In 7.

Calciferous glands or diverticula: Pair of diverticula in 9.

Intestine origin (caeca, typhlosole): In 12; (caeca, typhlosole lacking).

Nephridia: Holoic, absent from 2-11?, avesiculate.

Male organs: Testes/funnels in 10 (in testis sacs), seminal vesicles in 9 and 11.

Ovaries: In 13.

Prostates: Two pairs of long tubular prostates with short muscular ducts in 17 and 19.

Spermathecae: In 8 and 9, duct as long as ampulla; adiverticulate.

Gut contents: ?

Notes: *Eukerria kuekenthali* is reported less often than its sibling species *E. saltensis*.

Eukerria saltensis (Beddard, 1895)

Fig. 1.7a *Eukerria saltensis* Samford specimen, (a) anterior view with (b) prostates and

(c) spermatheca *in situ*, (d) prostomium, (e) laterally paired diverticula in 9, (f) cocoon with embryo visible.

Fig. 1.7b *E. saltensis* cocoons, lengths 2 mm (photo courtesy Dr Mark Stevens, NSW Agriculture for whom I identified the adult specimens to species).

Fig. 1.7c *E. saltensis* known World distribution (original).

Kerria saltensis Beddard, 1895: 225. [Type locality Valparaiso, Salto, Chile. Types in US National Museum (21025) and British Museum 1904:10:5:928)]; Michaelsen, 1900: 371; Michaelsen, 1907a: 23 (syn. *sydneyensis*).

Acanthodrilus sydneyensis Sweet, 1900: 124 . [From Sydney. Types? (from Fletcher's 'Museum Name' according to Michaelsen, 1907a)].

Kerria gunningi Michaelsen, 1912: 1. [From Pretoria, Transvaal. Types in Hamburg: 7490. See also Michaelsen (1913)].

Kerria nichollsi Jackson, 1931: 121, Pl. XVI, figs. 5,8,9,11. [From WA. Types?].

Eukerria saltensis: Michaelsen, 1935a: 40 (syn. *nichollsi*, *sydneyensis*); 1935b: 103 (syn. *nichollsi*); Gates, 1942: 67 (syn. after Pickford: *gunningi*); 1954; 1972: 270; Blakemore, 2002 (syn. *sydneyensis, gunningi, nichollsi*); Blakemore in Blakemore *et al.*, 2007a.

Taxonomic Note: Often misdated as "*Beddard, 1892*" when other *Eukerria* species were described by this author. *E. saltensis* is similar morphologically to *E. halophila* (Beddard, 1892: 357).

Diagnosis: *Eukerria* with spermathecal pores in 7/8/9 median to setal c lines. Nephridia possibly absent from anterior segments.

Distribution: South America and spread worldwide by human and other agencies: Spain (e.g. Valencia), Italy, USA [e.g. lower Columbia River, Washington/Oregon - see http://clr.pdx.edu/projects/cr_survey/cr-docs/LCRANSFinalReport.pdf although already known from Oregon, Texas, Gerogia, Florida, and North Carolina by Gates (1954; 1972: 270), also from South Carolina, Indiana - see http://www.inhs.uiuc.edu/~mjwetzel/AOGSMNP.PkChklst.html], Chile (El Salto, Valparaiso, Coquimbo, Quillota, also mid-Pacific Easter Island and the Iles San Fernandez: Robinson Crusoe Island, Santa Clara Island, and Alexander Selkirk Island), Argentina (Bella Vista, Cordoba), Brazil e.g. Minas Gerais (and from Sao Paulo reported by Righi, 1971), Costa Rica, Cuba and Mexico (Rodriguez, 1999); also Myanmar (Pyinmana, Mandalay, Lower Chindwin), India (Julka, 1988: 40), Vietnam (Thai, 2000), South Africa (Cape Province, Natal, Transvaal), New Caledonia, and newly from Japan (see Blakemore, 2006; Blakemore *et al.*, 2007a) and Taiwan (Shen *et al.*, 2008). In

Australia previously reported from NSW (Sydney, Paramatta and Blue Mtns.) and Victoria (e.g., Sweet, 1900; Michaelsen, 1907a; Blackwell & Blackwell, 1989), WA (Jackson, 1931), and now confirmed from Qld, and possibly from Tasmania. Material collected by Michaelsen from NSW in 1905 was sent to G. Pickford and is now in US Natl. Museum (Ref.). Seoul, in NIBR collection – **New record Korea**.

Locality: Samford (e.g. ANIC: RB.95.4.6), Closeburn, CSIRO Narayen (collector RJB) all in Qld; Whitton near Griffiths (collector J. Blackwell); Woodburn Island/Maclean (e.g. ANIC: RB.95.13.1), Lismore, Whitton and Deniliquin (ANIC: RB.95.2.1-2 collected 7.xii.1994 by M. Stephens), NSW; in QVM collection, Tasmania - new Australian records. From drain at Kuzuharagaoka Shrine, Kamakura, - several specimens collected 13.VI.2004 by RJB, Amanda Reid and Yuko Hiramoto; besides creek east of Hashimoto station, Machida-ku, Tokyo, 18.VIII.04, RJB; Fudogawa, Ojiyamakoen, Biwako, also from north basin (collected 31.I.07-1.II.07 and 1.X.07 by R.J.B.) in Japan; Seoul, Korea as noted above – **all new Asian records**. Florida – specimens identified for Dr Dan Shain at Rutgers Uni, NJ June, 2013.

Habitat: Limicolous, generally in irrigated or sodden soil, besides water courses or in drains, under rice, sugarcane, pasture soil. Can survive in clay soils (Blakemore, 1994).

Registration No.: Specimens in ANIC also QVM and deposited in Tokyo Museum.

Behaviour: Fairly docile although white prostomium probes; body readily extends and is easily broken; when in water specimens aggregate in coiled masses; coils on preservation and produces much mucus.

Length: 27-95 mm.

Width: Generally ca. 1 mm.

Segments: 97-131.

Colour: Clear, unpigmented but red from blood and dark from soil in gut; anterior faint, with brilliant, blue iridescence (note: some forms may appear white from coelomocytes in body cavity). Clitellum yellowy or white.

Prostomium: Epilobous, closed or open.

First dorsal pore: None.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment, **ab** absent on 17, **b** absent on 18-19. (3:1:3:1:10:0.44).

Nephropores: Not visible (in **ab** lines?).

Clitellum: 13½,14-20.

Male pores: On 18 in slightly inwardly bowed seminal grooves between pairs of

prostates equatorial in **ab** in 17 and 19.

Female pores: 14, variously reported as: paired longitudinal slits anterior to setae **a** almost at 13/14; or longitudinal slits just anterior to **b**; or only a single pore found in two specimens just anterior to **b** line on right hand side.

Spermathecal pores: Inconspicuous in 7/8 and 8/9 lateral between **b** and **c** lines, often closer to **c**.

Genital markings: None.

Septa: 5/6-11/12 present and thick.

Dorsal blood vessel: Single, continuous on pharynx.

Hearts: 9, 10 and 11; supraoesophageal vessel with commissurals in 10 and 11.

Gizzard: Weakly muscular barrel or pear-shaped gizzard in 7.

Calciferous glands or diverticula: Paired in 9, ventro-laterally discharging into oesophagus at 9/10, (glands are supplied by small capillaries and have thick walls and central lumen in cross section).

Intestine origin (caeca, typhlosole): Commences between 11-13.

Nephridia: Holonephridia commencing from around 7, avesiculate.

Male organs: Testes/funnels free and iridescent in 10; paired seminal vesicles in 9 or 9 and 11 (cf. Sweet: funnels in 11, seminal vesicles in ?11 and 12).

Ovaries: Large pair palmate in 13.

Prostates: Two pairs of thin elongate tubular prostates with short muscular ducts in 17 and 19, intercoiled and extending back several segments.

Spermathecae: Two pairs in 8 and 9; moderately small; ampullae may be bent at right angles to longer duct; adiverticulate non iridescent .

Gut contents: Fine soil and colloidal organic matter.

DNA: >JET128-11|Biwako specimen in Tokyo An-468.1|Eukerria_saltensis|COI-5P

ATGAGCTGGAATAACAGGTACTGGAATAAGAATAATTATCCGAATCGAACTAA
GACAGCCAGGCACATTTATAGGGAGGGATCAACTCTACAACACAATTGTAAC
AGCACACGCATTTCTTATAATCTTCTTCCTGGTTATACCAGTTTTTATTGGGGG
ATTCGGAAATTGACTCCTACCACTAATACTTGGTGCTCCTGACATAGCATTCC
CTCGACTTAACAACATGAGATTCTGACTTCTACCACCGTCCATAACGATCCTA
ATATTCTCCGCAGCGGTAGAAAAAGGGGCAGGTACAGGATGAACCCTATACC
CCCCCCTCGCTAGAAATATAGCACATGCAGGACCATCTGTAGACCTAGCAATC
CTATCCCTTCACCTAGCTGGGGCATCATCAATCCTCGGAGCAATTAACTTTATC

ACAACAATAATTAATATACGATGAAATGGAATACGCCTAGAACGTATCCCACT
ATTTACATGGGCAGTAATAATTACAGCGATACTCCTTCTACTCTCCCTTCCAGT
GCTAGCTGGGGCAATTACCATACTCCTCACAGATCGAAATTTAAATACATCAT
TCTTCGATCCCGCAGGAGGAGGAGATCCAGTTCTATATCAGCACCTATTC

>JET129-11|Biwako specimen in Tokyo An-468.2|Eukerria_saltensis|COI-5P

TTTAGGAATATGAGCTGGAATAACAGGTACTGGAATAAGAATAATTATCCGAA
TCGAACTAAGACAGCCAGGCACATTTATAGGGAGGGATCAACTCTACAACAC
AATTGTAACAGCACACGCATTTCTTATAATCTTCTTCCTGGTTATACCAGTTTT
TATTGGGGGATTCGGAAATTGACTCCTACCACTAATACTTGGTGCTCCTGACA
TAGCATTCCCTCGACTTAACAACATGAGATTCTGACTTCTACCACCGTCCATA
ACGATCCTAATATTCTCCGCAGCGGTAGAAAAAGGGGCAGGTACAGGATGAA
CCCTATACCCCCCCCTCGCTAGAAATATAGCACATGCAGGACCATCTGTAGAC
CTAGCAATCCTATCCCTTCACCTAGCTGGGGCATCATCAATCCTCGGAGCAAT
TAACTTTATCACAACAATAATTAATATACGATGAAATGGAATACGCCTAGAAC
GTATCCCACTATTTACATGGGCAGTAATAATTACAGCGATACTCCTTCTACTCT
CCCTTCCAGTGCTAGCTGGGGCAATTACCATACTCCTCACAGATCGAAATTTA
AATACATCATTCTTCGATCCCGCAGGAGGAGGAGATCCAGTTCTATATCAGCA
CCTATTC

Notes: Collected in relatively large numbers at CSIRO Narayen from sodden soil beside a water tank, where they were difficult to extract since they produced a viscous, 'gummy' exudate that adhered to their bodies which snapped in two when stretched. From Samford, they were found in very moist clay soil, coiled at 5-10 cm depth or active in the root zone in two locations and in association with several other earthworm species, including *Aporrectodea trapezoides.* Maclean specimens were collected form the delta of Clarance River in irrigated alluvial soil under sugarcane, found in association with *Zacharius zacharyi* Blakemore, 1997. Specimens of *E. saltensis* from Whitton and Deniliquin were collected from rice paddies where they were abundant and thought to be rather problematic as they attracted wading birds such as ibis (*Threskiornis* spp.) which muddied the water (M. Stevens pers. comm. and see Stevens & Warren, 2000; Stevens, 2003). In Japan, specimens were collected from a drainage channel beside road at Kamakura (similar specimens collected from Kochi, Shikoku Island were too damaged to reliably identify). It is not known if their spread into Japanese rice fields, where the

rice is generally transplanted unlike in Australia, is likely to be problematic or not.

In such habitats, this species may be easily confused with chironomid larvae (Diptera: Chironomidae).or aquatic microdriles such as tubificids that are called 'bloodworms"; although of similar size, these larvae and microdriles have body appendages unlike true 'earthworms' and can be more serious pests of rice paddies (e.g. http://www.rirdc.gov.au/reports/RIC/99_141.doc), but cf. *Dichogaster annae*.

This species was introduced along with lumbricids into cultivated soils in NSW, but failed to clearly demonstrate beneficial effects although air permeability of the red-brown earth soil was reportedly increased. (Blackwell & Blackwell, 1989). In glasshouse trials in studies by Blakemore (1994, 1997), they were found to have slight to negligible effect on plant yield and soil structure, and their small size and susceptibility to injury made them difficult to handle, and they probably require high moisture. An indifferent species in respect of such studies although, like other peregrine species, their ubiquity and range of distribution in Australia and Asia from a supposedly South American origin is quite remarkable.

Remarks: Gates (1972) provides data that shows this species to have both biparental and parthenogenetic reproduction; there is some evidence to suggest (internal?) self-fertilization of some isolated specimens in laboratory experiments.

If parthenogenetic degradation occurs and male organs are lost, then such specimens would presumably be insistinguishable from *Ocnerodrilus occidentalis*.

Superficially, *E. saltensis* may also be confused with octochaetid *Ramiella bishambari* and its ilk.

Note: Specimens I collected from Philippine rice paddy and thought were immature *E. saltensis* or some similar ocnerodrilid differed in their DNA barcodes, viz.:

>P0 (655bp) Philippines 1st worm sample what I thought was *Eukerria saltensis* from Lipa City conventional rice paddy, but it differs and may actually be Ramiella bishambari?
Sequence:
CCTTTACTTCATTCTAGGTGTATGAGCCGGAATGGTTGGGGCTGGTATAAGACTC
CTGATTCGTATTGAACTAAGACAGCCAGGAACATTTCTAGGAAGGGATCAACTAT
ACAACACAATCGTAACCGCACATGCATTCGTAATAATCTTCTTCCTAGTTATGCCA
GTATTCATCGGGGGATTTGGTAACTGACTCCTGCCCCTAATACTGGGCGCGCCCG
ACATAGCATTTCCTCGTCTCAACAACCTAAGATTCTGACTACTTCCGCCGTCACTC
ATTCTTCTTGTATCCTCGGCAGCAGTTGAAAAGGGGGCGGGAACCGGATGAACT
GTATACCCACCCCTTGCAAGGAATATTGCACATGCAGGGCCATCCGTAGACCTAG
CTATCTTCTCTCTCCACTTGGCCGGTGCATCATCAATCCTAGGTGCAATCAATTTC
ATCACCACGGTAATCAACATACGGTGAAATGGGTTACGACTAGAACGCATTCCAC
TATTTGTATGAGCCGTAGTAATTACAGTTGTTCTATTACTTTTATCACTACCTGTAC

TGGCTGGGGCAATTACCATATTACTAACAGACCGAAACCTTAACACCTCCTTCTT
CGACCCTGCTGGGGGAGGTGACCCAATTCTATATCAACACCTATTT
Blast result: *Hormogaster huescana* (HQ621980.1), 82%
P0 vs. P~8 Penalosa worm = 655/655(100%) – same species but different to Japan E. saltensis. P0 vs. JET128 *E. saltensis* from Japan = 80% too, i.e. different taxa.

Genus **Gordiodrilus** Beddard, 1892

Gordiodrilus Beddard, 1892: 75; Michaelsen, 1900; Gates, 1942: 65; 1972: 271.

Type-species: *Gordiodrilus elegans* Beddard, 1892 first described at Kew Gardens in soil from Lagos, Nigeria. Gates (1972: 271) remarks that this species has not yet been properly characterized as biparental populations are unknown, rather it is composed of anatomical morphs variously degraded by parthenogenesis.

Diagnosis: (see also Ref): Small, often limnic or in moist soil. Lumbricine. Digestive system, agiceriate, with a ventro-median calciferous gland in 9; intestinal origin in 12, without typhlosole and supra-intestinal glands. Male pores, if present, usually on 18 associated with paired prostatic pores on adjacent segments in 17 and/or 18 (or shifted posteriorly by up to three segments). Spermathecal pores usually two pairs in 7/8/9. Hearts in (9), 10 and 11. Nephridia holoic, avesiculate. Dorsal pores and pigment, lacking. Spermathecae, without discrete diverticula. Holandric, testes paired in 10 & 11.

Distribution: Tropical Africa, and transported to Caribbean, Asia, and now known from Australia – this is the first record. Five 'species' in soil imported to Kew Gardens from West Africa and West Indies were described as new by Beddard, 1892b [viz. *elegans* Beddard, 1892: 84 (Lagos), *ditheca* Beddard, 1892: 90 (Lagos), *dominicensis* Beddard, 1892: 91 (Dominica), *robustus* Beddard, 1892: 82 (Lagos?; syn. *congicus* Michaelsen, 1936 from Leopoldville, Belgian Congo), *tenuis* Beddard, 1892: 75 (Asaba, E of Benin?)]. The type-species complex appears peregrine plus *Gordiodrilus habessinus* Michaelsen, 1913 is considered exotic in parts of Brazil (Brown & Fragoso, 2007: 67).

Notes: Most, if not all, gordiodriles are parthenogenetic with unpredictable degradation of reproductive organs, thus constant somatic structures become more useful for classification (Gates, 1942). Unraveling the gordian knot of gordiodrile systematics is beyond the scope to this study, however the somatic similarities (and often co-incidental distibutions) of the 'species' belonging to *Gordiodrilus*, *Ocnerodrilus* and *Eukerria* are noted in the current accounts that suggest their common origins.

Gordiodrilus elegans Beddard, 1892

Fig. 1.8 *Gordiodrilus elegans*-group, Biloela specimen 1: (a) ventral view, (b) prostates and (c) sub-oesophageal 'calciferous' gland displaced posteriorly and (d) spermathecae *in situ*, (e) ventral view same specimen.
Fig.1.9 *Gordiodrilus elegans*-group, Biloela specimen 2.

Gordiodrilus elegans Beddard, 1892a: 84, figs. 1, 6A, 7. [Type locality, (under ICZN, 1999: Art. 76.1.1) Lagos, Nigeria in soil taken to Kew Gardens. Types in British Museum listed as "*BMNH 1904:5:607*" by Reynolds & Cook (1976: 97) but later corrected to 1904:10:20:439]; Michaelsen, 1900: 374; Gates, 1972: 271 (syn. *travacorensis*, *unicus*, *peguanus*, *paski*).

Gordiodrilus travancorensis Michaelsen, 1910: 98. [Type locality Nedumangad, India. Types in Hamburg Museum].

Gordiodrilus paski Stephenson, 1928: 1. [Type locality Kigoma Harbour, Lake Tanganyika. Type material BMNH 1922:10:13:41-2].

Gordiodrilus unicus Stephenson, 1931: 79. [Type locality Bhamo, Myanmar. Type in the British Museum].

Gordiodrilus peguanus Gates, 1942: 85. [Type locality Rangoon. Types destroyed during World War II but Reynolds & Cook (1976) list additional material as ZSIC 3110, BMNH 1926:6:5:26-8, USNM 19662].

Gordiodrilus honacanus Cernosvitov 1942. [Locality? Types?]. [Said by Gates (1954: 246) to be distinguished from prior *peguanus* only by characteristics that may be explainable as due to incomplete development, individual variation, or misinterpretation of conditions in rather difficult material. Omitted from Reynolds & Cook (1976)]. **Syn. nov.**

Diagnosis: *Gordiodrilus* with spermathecal pores in 7/8/9 in setal b lines; male organs variable.

Distribution: Original homeland may be in tropical Africa (Stephenson, 1931b: 36; Gates, 1972: 271). Parthenogenetic morphs widely but infrequently reported, e.g. from Kew Gardens, Myanmar, Vietnam (Thai, 2000), India, Bangladesh, East and West Africa, Egypt, Sudan, Abyssinia, Madagascar, Zanzibar, Puerto Rico, Bonaco Island (Caribbean), from Sao Paulo, Brazil (as *G. paskii*) by Righi, (1968), ?Dominica, and now from Biloela, Qld – this the first record for Australia (on which the following account is based).

Habitat: Biloela in cultivated, black alluvial clay.

Registration No.: Several specimens collected by RJB, 18-20/March/1992 in ANIC.

Behaviour: Docile when handled.

Length: 35-45 mm (cf. Gates 26-47).

Width: c. 1 mm.

Segments: Ca. 100 (intersegmental furrows indistinct around clitellum).

Colour: Anterior 7 segments faint brown and iridescent, otherwise pigmentless; in life, cream calciferous gland visible through cuticle in 9 or 10 followed by red hearts anterior to the raised clitellum (where developed).

Prostomium: Open (or closed) epilobous or zygolobous.

First dorsal pore: None.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 closely paired, ab absent from 17 and 18 (4:1:4:1:16:0.5).

Nephropores: Visible in clitellar region, lateral intersegmental in c lines.

Clitellum: Indistinct 14-19 (range 12-20, Gates, 1972).

Male pores: Presumably in seminal grooves (in 17/18?).

Female pores: Paired on 14 anterior to b.

Spermathecal pores: 7/8 and 8/9 in b lines.

Genital markings: None.

Septa: Present from 5/6, weak.

Dorsal blood vessel: Single, splits on oesophagus.

Hearts: In (9), 10 and 11.

Gizzard: None.

Calciferous glands or diverticula: Large, single, central heart-shaped (or pear-shaped) yellowish calciferous gland, ventral and centrally placed beneath oesophagus in 9. Has thick walls and largish central lumen on bisection with small central opening to gut.

Intestine origin: 12.

Nephridia: Holoic.

Male organs: Testes/funnels in 10 and 11, (seminal vesicles in 9 and 12).

Ovaries: In 13, rosette shaped with oviducts opening into 14.

Prostates: Two pairs in 17 and 18, long and thin tubular glands with short muscular ducts, U-shaped and extending back several segments.

Spermathecae: Two pairs in 8 and 9, each with a curved duct which bears an opposed pair (at least?) of intramural, iridescent diverticula, in midriff or closer to junction of spherical ampulla (cf. Gates "*with intramural seminal chambers in a middle portion of*

the duct").

Gut contents: Fine soil (organic matter?).

Notes: Specimens were found in cultivated, black alluvial clay soils in DPI experimental site at Biloela in association with *Ocnerodrilus occidentalis* (in ratio of approx 2:1 in favour of *O. occidentalis*). Distribution was patchy with densities of both these small species combined approached 400m^{-2} in places mostly in the top 10 cm of soil, while some samples gave low counts. In a glasshouse trial, a combination of these two species had only a marginal influence on plant yield and both had only moderate survival (Blakemore, 1994a).

Remarks: Several variations were found to the above account: two specimens only had a single pair of spermathecal pores in 8/9; one other specimen, had a heart-shaped calciferous gland ventrally in 9 and a similar shaped bladder (or outgrowth of oesophagus) dorsally in 11 which was well supplied with capillaries. Common features are the two pairs of prostatic pores in 17 and 18, but the location of these are sometimes difficult to determine because the setae are small and intersegmental furrows faint.

In an informal *Gordiodrilus elegans* species-group, the specimens here are almost identical to the *G. paski* Stephenson, 1928 constituent from Lake Tanganyika and, by synonymy of *G. unicus* Stephenson 1931, from Myanmar (with a single abnormal specimen) and *G. peguanus* Gates, 1942, from Myanmar, India and Puerto Rico; this group possibly also includes *G. wemanus* Michaelsen, 1937 from the Tana River, Kenya.

Gates (1972) considered the representative 'species' of *G. elegans* to be a complex of parthenogenic polymorphs: the *G. peguanus* morphs have prostatic pores in 17 and 18 (as in *G. elegans s. s.*) and male pores in 17/18; the *G. travencorensis* morphs have prostatic pores in 18 and 19; and the *G. unicus* morphs have, or lack, prostatic pores in 18, or have various and irregular combinations in 17-19 (Gates, 1942; 1972). Stephenson (1931) first described *G. unicus* on a single mature specimen with tubular prostates three in number on the right side (in 17, 18 and 19) and two on the left (in 17 and 19). From such data, Gates (1972) theorized sex-prostatic (as found in the genus *Nannodrilus*) or polyprostatic ancestral stages for ocnerodrile evolution, that may also be precursors to acanthodrile and megascolecid forms.

Genus ***Nematogenia*** Eisen, 1900

Ocnerodrilus (*Nematogenia*) Eisen, 1900: 112.

Nematogenia : Michaelsen, 1900: 376; Stephenson, 1930: 862; Gates, 1972: 272.

Type-species: *Pygmaeodrilus lacuum* Beddard, 1893.

Diagnosis: Lumbricine. Digestive system with two small gizzards in 6 and 7; ocnerodrile diverticula paired in 9; intestinal origin in 12, without typhlosole and supra-intestinal glands. Male and prostatic pores combined or discrete, paired on 17. Spermathecal pores one pair in 8/9. Last hearts in 11. Nephridia holoic, avesiculate. Dorsal pores present. Pigment lacking. Spermathecae, adiverticulate. Metandric (testes one pair only in 11).

Distribution: Tropical Africa (Guinea to Congo). *Nematogenia panamaensis* (Eisen, 1900) is widely distributed in its African homeland and transported to Central and South America; the Caribbean; India and southeast Asia, (cf. distribution of *Gordiodrilus*). The genus comprises two species that may be synonymous.

Provisional key to *Nematogenia* species

Clitellum from ½13-½26; male and prostatic pores combined ……. *N. lacuum*

Clitellum from 13,14-21,24; male and prostatic pores discrete ……. *N. panamaensis*

Nematogenia lacuum (Beddard, 1893: 259) found at Kew in soil imported from Lagos, it is a small species (25mm) also claimed from the Congo (Ghabbour, 2009) that is not adequately characterized although types are in British Museum (1904:10.20.1047-50). A recent report is from Madagascar (Ref.), and from a few sites in Durban and Pietermaritzburg, South Africa (Zicsi, 1998). It is possibly a senior synonym of *N. panamaensis* (see **Remarks** after this species' description below).

"***Nematogenia occidentalis***" reported as a Philippines invasive by Indian scientist, Ravindra Joshi, is probably a *lapsus* for *Ocnerodrilus occidentalis* or *Nematogenia panamaensis*.

Nematogenia panamaensis (Eisen, 1900)

?Pygmaeodrilus lacuum (part?) Beddard, 1893: 259, figs. 13-16. [First described at Kew Gardens in soil from Lagos, Nigeria, the type-locality (under ICZN, 1999: Art. 76.1.1). Types BMNH:1904:20.1047-50].

Ocnerodrilus (Nematogenia) lacuum var. *panamaensis* Eisen, 1900: 127, Pl. 9, figs. 55-

65, 67. [Type locality Panama. Types, probably none].

Nematogenia josephina Cognetti, 1904: 3. [Type locality San José, Costa Rica. Types in Torino, 141B]; Stephenson, 1930: 862.

Nematogenia lacuum (part?): Michaelsen, 1900: 376; 1922: 21.

Nematogenia panamaensis: Michaelsen, 1900: 376; Michaelsen, Michaelsen, 1910c: 114; 1915: 222; 1916: 20; Stephenson, 1923: 483; Gates, 1972: 272 [syn. *josephina*, *lacuum* (part?)]; 1982: 67.

Ocnerodrilus lacuum: Sims & Gerard, 1985; 1999: 139 [*lapsus* for *Pygmaeodrilus lacuum*].

Note: Name sometimes misspelt "*P. panamensis*" or "*P. panamaenensis*".

(The following description is compiled from authors in the synonymy above).

Diagnosis: *Nematogenia* with spermathecal pores in 8/9 in b setal lines; nephridia absent from anterior segments.

Distribution: Africa: Guinea (and Sao Tome island - Cs. Csuzdi pers. comm.), Liberia, Nigeria, Cameroons, Fernando Po, Congo and East Africa. Transported to Panama, Jamaica (Sims, 1987), Fernando Po, India (Julka, 1988; Halder, 1999) and Sri Lanka, Philippines, Costa Rica, Venezuela (interception at San Juan), Bahamas (e.g. Michaelsen, 1921) and Brazil (where it may also be endemic); reported from Vietnam by Thai (2000).

Habitat: A tropical lowland species found at sea-level to 1,160m (in Costa Rica).

Behaviour: ?

Length: 40-55 mm (25 mm *lacuum*).

Width: 1-2 mm.

Segments: 95-124.

Colour: Unpigmented.

Prostomium: Epilobous, small and tapering posteriorly.

First dorsal pore: 8/9 (or behind) (or from 6/7 *lacuum*).

Setae (ratio of aa:ab:bc:cd:dd:U): 8 closely paired, ab absent from 17; (aa<bc, ab=cd).

Nephropores: Inconspicuous in or close to cd lines (throughout?).

Clitellum: Saddle-shaped 13,14-21,22,23,24 (Gates), cf ½15-½22 (Michaelsen) (saddoe-shaped 13-26 *lacuum*).

Male pores: On porophores just behind prostatic pores on 17 in position of absent setae (and to my mind that implies that there would be penial setae within the pores).

Female pores: Paired on 14 near b setae.

Spermathecal pores: 8/9 in b lines.

Genital markings: None.

Septa: Present from 4/5; 5/6-9/10 muscular.

Dorsal blood vessel: ?

Hearts: In (9), 10 and 11.

Gizzard: Weak in 6 and 7.

Calciferous glands or diverticula: Paired in 9.

Intestine origin: 12; typhlosole absent.

Nephridia: Holoic, avesiculate(?) (commencing from segment 6 in *lacuum*).

Male organs In 11, seminal vesicles large in 12.

Ovaries: In 13 with oviducts; no egg-sacs.

Prostates: One pair in 17, long tubular glands with narrower muscular ducts about as long as two segments.

Spermathecae: One pair in 9, ampulla on slender duct usually sinuous or in short loops; adiverticulate.

Gut contents: (Sand in *lacuum*).

Remarks: Presumed to be biparental. *Nematogenia panamaensis* (Eisen, 1900), according to Gates (1972: 273) and Righi (1984), is possibly a junior synonym of the type-species – *Pygmaeodrilus lacuum* Beddard, 1893 from West Africa and/or Brazil – as only tenuous differences in characters separate them, as given in the key above. In fact, Gates (1982) thought that the genus was native to Latin America and Righi (1984) found specimens in Matto Grosso, Brazil that were intermediate between *N. lacuum* and *N. panamaensis* and therefore he argued that they should be combined in synonymy under the former name. Michaelsen (1935b:103) when combining two *Eukerria* species said "*the shape and length of the clitellum is of no importance*" – this may equally apply to *Nematogenia* spp.

Further study is required to determine the origin and distinction of the species.

Genus ***Ocnerodrilus*** Eisen, 1878

Ocnerodrilus Eisen, 1878: 1; 1900: 110 (including *Leiodrilus, Pygmaeodrilus Ilyogenia, Nematogenia, Haplodrilus, Enicmodrilus sanxavieri*); Michaelsen, 1900: 377 (?excluding *Leiodrilus, Ilyogenia sanxavieri, I. taste, I. tepicensis, I. africanus, Haplodrilus*); Stephenson, 1930: 860 (excluding *Liodrilus* and part of

Ilyogenia); Gates, 1972: 273; Blakemore, 2010 (?syns. include *Phoenicodrilus* Eisen, 1895 (type *P. taste*), *Enicmodrilus* (type *Ocnerodrilus agricola* Eisen, 1893), *Ilyogenia*, *Pygmaeodrilus* Michaelsen, 1890); *Liodrilus* Eisen, 1900 (type *O. eiseni* Beddard, 1891, redescribed by Eisen (1893)].

Type-species: *Ocnerodrilus occidentalis* Eisen, 1878 originally described from Eisen's vineyard at Fresno, California.

Diagnosis: Setae lumbricine. Dorsal pores and pigment lacking. Nephropores near setal b lines. Digestive system, agiceriate. Calciferous glands (ocnerodriline diverticula) one pair in 9. Vascular system, with paired extra-oesophageals which pass into calciferous glands before joining the supra-oesophageals, last hearts in 11. Holoic. (Spermathecal diverticular missing, and spermathecae also sometimes absent, but this variable).

Remarks: A mishmash genus of just 7 species (Brown & Fragoso, 2007) or more if generic synonyms are included (Blakemore, 2010). Gates (1972: 274) considered *Ocnerodrilus occidentalis* to be a parthenogenetically degraded complex and said; "O. beddardi, guatemalae, hendrici, sonorae *Eisen, 1893,* O. calwoodi *Michaelsen, 1898* [1899] *and* O. mexicana *Eisen, 1900* [sic lapsus pro *O.* (*Enicmodrilus*) *mexicanus* Eisen, 1900: 124] *are believed to be morphs of occidentalis rather than species*." Many of these names were included in the genus *Ilyogenia* characterized by spermathecal pores in 8/9; but its type-species, *Ilyogenia africana* Beddard, 1892/3, is also probably a merely thecate morph of *O. occidentalis*, suggesting these genera should be combined. *Ilyogenia comondui* (Eisen, 1900) - originally in *Ocnerodrilus* (*Enicmodrilus*) from Baja California, is also claimed as a synonym by Fragoso (pers. comm. Sept. 2006). The genera *Phoenicodrilus* (type *Phoenicodrilus taste* Eisen, 1895 from Baja California and other regions of Mexico where it sometimes inhabits bromeliads, and in Chile) and *Enicmodrilus* (type *Ocnerodrilus agricola* Eisen, 1893 from Guatemala) were both included in *Ocnerodrilus* (*Ilyogenia*) by Michaelsen (1900: 378) but Gates (1972: 273) seems to exclude at least the first of these. The genus *Phoenicodrilus* is briefly described below. One of Eisen's 1893 papers is online here.

Genus *Pygmaeodrilus* Michaelsen, 1890 (type *Py. quilimanensis* Michaelsen, 1890 from the Zambesi, plus a few other species including *Py. amapaensis* Righi, 1988 from Brazil) appears similar to *Ocnerodrilus* Eisen, 1878 differing only on such parthenogenetic characteristics as absence of spermathecae or spermathecal diverticula; it probably belongs in *Ocnerodrilus* synonymy.

Genus *Liodrilus* Eisen, 1900: 112 [?corr. of *Leiodrilus* (Michaelsen, 1900: 378)]

with type *O. eiseni* Beddard, 1891: 563 from Guayana, was dubiously separated on its spermathecal pores in 7/8; two species, also known from Brazil (Christoffersen, 2008).

Another possible thecate synonym of *O. occidentalis* is *Ocnerodrilus* (*Ilyogenia*) *asiaticus* Chen & Hsu in Chen, Hsu, Tung & Fong, 1975 that was found in Nanking. Two further uncertain species, *O. simplex* (Cognetti, 1904), originally in *Ilyodrilus* - a microdrile genus, and *O. calwoodi* Michaelsen, 1899 (= *O. occidentalis*) are reported as probable introductions to the Canaries [http://www.faunaeur.org/full_results.php?id=177958 ; http://www.gobcan.es/medioambiente/biodiversidad/ceplam/bancodatos/biota/AnexoDudosasPorConfirmar.pdf June, 2006].

Distribution: What Gates (1982: 16) calls "*Another Afro-American congeries with endemics in the tropical portions of both continents*" i.e. tropical and subtropical America and Africa. The type-species is circummundane in the tropics; below are first records from Australia and Tasmania.

Ocnerodrilus occidentalis species-complex Gates, 1972

Ocnerodrilus occidentalis Eisen, 1878

Fig. 1.10a *Ocnerodrilus occidentalis*, aclitellate Samford specimen, (a) ventral view, (b) ocnerodrile diverticula in 9, (c) prostomium and (d) lateral view. Aprostatic and athecate.
Fig. 1.10b *Ocnerodrilus occidentalis* clitellate Biloela specimen, (a) ventral view, (b) ocnerodrile diverticula from 9, (c) lateral view.
Fig. 1.11. Korean specimen with either prostate or parasitic nematode in region of 17-18

Ocnerodrilus occidentalis Eisen, 1878: 10. [Type locality Fresno County, Types in US Natl. Mus.?]; Eisen, 1893: 267 + figs.; Michaelsen, 1900: 377 (syn. *O. o.* var. *sinensis*); Gates, 1972: 273 (syn. *tenellulus*); Gates, 1973a; Lee, 1981: 567; Gates 1982: 16 (syn. *O. beddardi, guatemalae, hendriei, sonorae* all by Eisen, 1893, as well as *comondui, mexicanus* both by Eisen, 1900, *O. calwoodi* Michaelsen, 1898; and possibly Eisen's Guatemala species: *O. agricola, contractus, limicola, rosae, tuberculatus*).

?Ilyogenia africana Beddard, 1893b: 703. [At Kew Gardens in soil from Durban, South Africa (type locality under ICZN, 1999: Art. 76.1.1). Types missing from British Museum]. [Note: Sims & Gerard (1985:139) possibly mistake *Nannodrilus africanus* Beddard, 1894: 388 for *Ilyogenia africana* Beddard, 1893: 703; and in

Reynolds & Cook (1976: 66) the species is confused in the tubificid genus *Ilyodrilus* Eisen, 1879. Michaelsen (1913: 496) and Zicsi (1998) provide additional data on synonymy and its distribution in Pietermaritzburg].

Ocnerodrilus beddardi, guatemalae, hendriei, sonorae all by Eisen, 1893.

?*Ocnerodrilus agricola, contractus, limicola, rosae, tuberculatus* all by Eisen, 1893 from Guatemala.

Ocnerodrilus calwoodi Michaelsen, 1898/9 (believed by Gates, 1982 to be closest to an antipicated amphimictic population).

Ocnerodrilus oc. sinensis Eisen, 1900: 115. [Introduced with Chinese plants. Types?].

Ocnerodrilus comondui, mexicanus both by Eisen, 1900.

?*Ocnerodrilus tuberculatus* Eisen, 1900 from Guatemala.

Ocnerodrilus tenellulus Gates, 1945: 223. [Type locality Allahabad. Types in Indian Museum now lost?].

Note: Subspecies ***Ocnerodrilus occidentalis arizonae*** Eisen, 1900: 116 [from Phoenix, Arizona] and ***Ocnerodrilus mexicanus hawaiiensis*** Eisen, 1900: 124 [from San Francisco, brought from Honolulu, Hawaii – see Blakemore, 2007] may be synonymous with *O. occidentalis*, or with one of its parthenogenetic morphs listed above.

Diagnosis: *Ocnerodrilus* (lacking gizzard) without spermathecae. Male organs present (in 17) or absent. Nephridia possibly absent from anterior segments.

Distribution: Pan-tropical, especially if all the reports of various parthenogenetic morphs are included, less frequently found in temperate regions; the original home is thought to be in Central or South America. Examples of distribution are: Myanmar, Andaman and Nicobar, India, Pakistan, Sri Lanka, Singapore, China, Hainan, Japan, Philippines, Solomons and New Hebrides, California, Arizona, Mexico, Cuba (Gates, 1979), St Thomas, Denmark, Germany, Italy, Greece [this is an earlier record also re-claimed by Szederjesi, 2015)], Cape Verde Islands, Canaries. Rhodesia, Great Comoro, Israel, Lebanon, Jordan (Csuzdi & Pavlicek, 2005: 71), Central Asia SSSR. Gates (1972: 274) said that he included Denmark, Greece, Lebanon, Japan and possibly Germany, due to interceptions by Gates (1964). Until about 1893, *O. occidentalis* was found only in Eisen's vinyard 6 miles east of Fresno in the San Joaquin Valley of California but it was certainly an introduced taxon there. Now known from mainland Australia and Tasmania (**new records** by Blakemore, 1994; 2000; 2002). Recently (14.II.2012) collected from Jeju Island by RJB – **New Record Korea.**

Locality: Samford, St Lucia, Brisbane; Kingaroy; Biloela, in Qld; Buddaroo Plateau,

NSW; Kyabran Irrigated Dairy Research Institute nr. Tatura, Victoria; and from domestic pipeline blocked by plant roots at Invermay, Tasmania. All are new Australian records, and Korea as noted above (single specimen in NIBR, Incheon).

Habitats: A range of soils, from drained sandy to moist clays; also aquatic in irrigation channels, drains, ditches and lake edges. Algal mats, Municipal dumps. Greenhouses (Denmark and Germany). Cernosvitov (1942) reported it from "*hot water at the edge of Lake Gaua*", Gaua Is. in the Banks Group, VanuaTu (see Lee, 1981: 567). The volcanic lake on Gaua is called Lake Letas and is a geothermally heated freshwater lake with a temperature of 32ºC, where only eels and shrimps can survive (according to Google).

Registration No.: Numerous specimens, most collected by RJB some kept in ANIC; and QVM 14:3647, Invermay, Launceston, 30.vi.1997, R.J.B., from stormwater pipe blocked by roots, found tangled in wet roots with many tubificids, (two damaged specimens, both dissected). These latter two specimens had the distinctive 'ocnerodrilid diverticula' paired in segment 9, however, these specimens had two pairs of spermathecae in segments 8 and 9, rather than the typical bithecal arrangement and are thus probably morphs of this 'species' (see Blakemore, 2000).

Behaviour: Docile; coils on preservation.

Length: 12-37 mm.

Width: c. 1 mm.

Segments: 70-85

Colour: Anterior segments slightly dark and iridescent but otherwise colourless with gut contents and dorsal blood vessel visible; clitellum yellowy.

Prostomium: Open epilobous.

First dorsal pore: None.

Setae (ratio of aa:ab:bc:cd:dd:U): Lumbricine, a (and b?) missing from 18 (always?); (6:1:5:1:18:0.5).

Nephropores: Not seen.

Clitellum: Most often in 13-20, range ½13,13,14-18,19,20 tumid and saddle shaped or annular, setae faint but retained.

Male pores: 17, small pair on protuberances in position of ab (or absent).

Female pores: 14, faint lateral slits just anterior to b.

Spermathecal pores: None; (?or spermathecae variously present in some morphs e.g. possibly *Ilyogenia africana*).

Genital markings: None.

Septa: Present from 4/5 onwards.

Dorsal blood vessel: Single continuous on pharynx.

Hearts: In 9 on either side of oesophagus, and as large vessels filled with blood in 10 and 11.

Gizzard: None.

Calciferous glands or diverticula: Pair of 'ocnerodriline' glands in 9, a shiny, rusty-brown colour, discharging to oesophagus in 9/10.

Intestine origin (caeca, typhlosole): 12; acaecate, atyphlosolate.

Nephridia: Holoic, a pair of large saccular nephridia per segment seen from about 8, discharging in b lines.

Male organs: Seminal vesicles in (9 or 11? and) 12 seen in only one specimen; (in other morphs?).

Ovaries: 13, small (with about a dozen oocytes each).

Prostates: Absent, reduced or, if present, variously as long thin ducts along nerve cord as far as segment 30, or coiled and confined to 17; (various morphs?).

Spermathecae: Not found; (present in some morphs and then oval sacs, with or without diverticula?).

Gut contents: Fine soil and dark and pale organic matter.

Notes: The pharynx in about 3-5 is surrounded by highly opalescent glandular mass.

Regeneration: Gates (1972: 274) noted head regeneration from 12/13 or as far back as 21/22 (but with monstrosities), and tail regeneration backwards from 20/21-34/35. Thus it is just feasible to obtain two regenerated specimens from a bisected worm.

Remarks: Specimens were collected in relatively high numbers only from cultivated fields at Biloela (see reference above to *Gordiodrilus elegans*). Samford samples were found under pasture and in association with two other small species of *Drawida* and *Amynthas*. The Tasmanian specimens were obtained from roots that blocked a drain (in my backyard!). Incidental collecting by the author indicates that this species is fairly widespread, especially in moist habitats, and it may have been overlooked previously due to its small size and somatic simplicity inferring immaturity. In a series of glasshouse experiments (Blakemore, 1994a, 1997) this species was found to have marginal survival and slight influence on plant growth and was thus considered a benign introduction to the Australian fauna.

Inclusion of various stages of parthenogentic degradation under this taxon name, as mooted by Gates (1972; 1973), would considerably increase its synonym distribution.

Phoenicodrilus Eisen, 1895

Phoenicodrilus Eisen, 1895: 63; 1896: 171; *Ocnerodrilus* (part). Michaelesen, 1900: 377; (part); Gates, 1977: 481; 1982: 17.

Type-species: *Phoenicodrilus taste* Eisen, 1895: 63 from Baja California.

Diagnosis: Male pores on 17. Clitellum 13,14-18. Spermathecal pores in 7/8. Prostates absent (or tubular in 17). Agiceriate. (Calciferous?) ocnerodrilid diverticula paired in 9. Holoic. No dorsal pores.

Distribution: Latin America and the Caribbean (by introduction); Africa for three species, at least that were transfered from *Ilyogenia* by Gates, viz.: *P denti* (Stephenson, 1930) from two East African specimens, *P. granviki* (Michaelsen, 1921) several macerated Nairobi specimens, and *P. pretorianus* (Stephenson, 1925) from eight specimens from South Africa.

Remarks: Variously included in genera *Ocnerodrilus* or its then sub-genus *Ilyogenia* in the past (e.g. Michaelsen, 1900: 380; Eisen, 1900: 122). Said by Eisen (1895, 1896) to differ from Ocnerodrilus only in lack of a prostate gland, although this is a variable characteristic common with parthenogenetic degradation and is now known from the type, thus the two genera should perhaps be recombined [cf. Brown & Fragoso (2007) and Christoffersen (2008) who appear to maintain the genus with just two species: the type and *P. calwoodi*].

Phoenicodrilus calwoodi (Michaelsen, 1899: 181) from St Thomas, Cuba , Colombia (its home?) and a report from the Canaries; it differs from type mainly in having prostates – thus it is possibly a synonym or, as noted above, a member of the *Ocnerodrilus occidentalis* species-group.

Phoenicodrilus taste Eisen, 1895

Phoenicodrilus taste Eisen, 1895: 64. [Sierra El Taste & Pescadero, Baja California. Types?]; Eisen, 1896: 172; Gates, 1982: 67. [Sometimes mispelt "*P. torte*"].

Ocnerodrilus (*Ilyogenia*) *taste* : Eisen, 1900: 133 [from Tepic, Mexico City, and Morelos (at or above 3,000m); syn. *tepicensis*], fig. 135; Michaelsen, 1900: 380.

Phoenicodrilus tepicensis Eisen, 1896: 172. [From Tepic, Mexico. Types?].

Ocnerodrilus santi xavieri Eisen, 1900: 121 (corr. *santixavieri*). [From Baja California. Types?].

Distibution: Baja California; Mexico (Tepic, Mexico City, Morelos, San Blas); Chile (Isla Juan, Canal Wide) (Blakemore, 2007); St Helena (Kenya, Namibia, South Africa, Zimbabwe?) (Gates, 1982: 17, 67).

Diagnosis: Size 35-70 x 1-2.5 mm. Clitellum 14-½19,19. Male pore in ab on 17. Spermathecal pores in 8/9 in ab. Holandric, seminal vesicles in 9 & 12. Prostates absent (or small in 18 in *santixavieri*). Spermathecal ampulla warty (*taste*), duct short.

Remarks: Fragoso (pers. comm. Sept. 2006) includes *Phoenicodrilus tepicensis* Eisen, 1896 and *Ocnerodrilus santixavieri* Eisen, 1900 in synonymy, perhaps from Gates (1970) – see Blakemore (2007).

Sub-family **Malabariinae** Gates, 1966

Genus ***Malabaria*** Stephenson, 1924

Malabaria Stephenson, 1924: 356.

[Syns. *Aphanascus* Stephenson, 1924: 360 (Type-species *A. oryzivorus* Stephenson, 1924); *Filodrilus* Chen, 1938: 422 (Type-species *F. levis* Chen, 1938)].

Type-species: *Malabaria paludicola* Stephenson, 1924.

Diagnosis: Acanthodriline. Lumbricine. Dorsal pores and pigment lacking. Digestive system, with gizzard in 7. Calciferous glands and typhlosole absent. Holoic.

Distribution: India, Myanmar, Vietnam, and Hainan (at least the latter by introduction?).

Remarks: Endemic to Peninsular India; one variable 'species' - *Malabaria levis* (Chen, 1938), known only from parthenogenetic morphs, appears to have been transported.

Gates (1972: 263) said that parthenogenesis was rampant within the sub-family and advised caution in naming new species.

Malabaria levis (Chen, 1938)

Filodrilus levis Chen, 1938: 423. [From Fo-peng (Po-peng?), Hainan. Types?].

?*Malabaria levis*: Gates, 1942: 92; 1972: 265.

Distribution: Myanmar, Vietnam, Hainan and - (Julka & Paliwal, 1995; 2005) - India.

Diagnosis: Prostomium epilobous. Length to 87 by 1 mm. Segments ca. 195.

Lumbricine. Spermathecal pores on pair lateral to b setal lines in 8/9. Male pores combined with prostatic pores in transverse slit on 17. Genital markings across 8/9, in 8 and sometimes in 18. Septa present from 5/6. Holandric: seminal vesiclesin 11, 12. Prostates tubular. Spermathecae long enough to reach to 25, often coiled in 8 or 9.

Remarks: Parthenogenetic morphs common with elimination of spermathecae and/or prostates and/or genital markings (Gates, 1942: 97, table; 1966). Possibly related to Indian *Malabaria biprostata* Aiyer, 1929 from Travancore, South India.

Genus ***Thatonia*** Gates, 1942

Thatonia Gates, 1942: 101.

Type-species: *Thatonia gracilis* Gates, 1942 (syntype in SI 126926) (syn. *Th. parva*?).

Diagnosis: Acanthodriline. Lumbricine. Dorsal pores and pigment lacking. Gizzard in 7. Calciferous glands intramural in 9-10. Typhlosole absent. Holoic.

Distribution: India, Myanmar, Vietnam, and Laos (all natural?).

Remarks: *Thatonia gracilis* from Andamans and Myanmar is polymorphic. *Thatonia exilis* Gates, 1945 is possibly in part transported by rivers or by man (Gates, 1972: 265).

Key to *Thatonia* species (after Gates, 1972: 266).

1. Spermathecal pores at 7/8/9 in or close to ab lines 2

   Spermathecal pores in 8/9 at mid-bc ..... *Th. exilis* from the Deccan, India.

2. Ventral setae of 8-9 enlarged; prostate-like GM glands absent ... *Th. gracilis*

   Ventral setae not enlarged; GM glands in 20 ... *Th. parva* from the Deccan, India.

Th. bolangirensis Julka, 1976 and *Th. sambalpurensis* Julka, 1976 are from Orissa, India.

Thatonia exilis Gates, 1945

Thatonia exilis Gates, 1945: 216. [Type locality Allahabad, India. Types?]. Gates 1972: 266; Samphon 1990: 110; Thai 1983: 121; Thai 2000a: 311; Thai 2000b: 1.

Notes: Mispelt "*exilus*" by Reynolds & Cook (1976: 100).

Diagnosis: *Thatonia* with spermathecal pores in 8/9.

Distribution: Reported from India, Laos and Vietnam (Thai & Samphon, 1991; Thai, 2000).

Family **Acanthodrilidae** Claus, 1880

Acanthodrilidae Claus, 1880: 479; Vejdovsky, 1884; Benham, 1890; Michaelsen, 1900; Gates, 1972; Blakemore, 2000 (with latter concept differing greatly from Gates' but closer to Michaelsen, although including Diplocardiinae Michaelsen, 1900).

[Eisen (1900: 151) has subfamily Microscolecinae (for *Microscolex, Yagansia* and *Rhododrilus*) and Michaelsen (1910: 53) had several sub-groups, viz. Eodrilacea, Diplotremacea (same as previous group), Neodrilacea, Acanthodrilacea, Maheinacea, Chilotacea and Howascolacea, some of which may merit restoration for sub-families].

Type-species and genus: New Caledonian *Acanthodrilus ungulatus* Perrier, 1872: 89 [?syn. *A. layardi* Beddard, 1886: 168, Pl. XIX from Noumea, New Caledonia (map)].

Diagnosis: Male pores acanthodriline, i.e., paired usually on 18 (or further back one, two or more segments e.g. in 19-21 in several *Acanthodrilus* or *Diplocardia* spp.) separate from pores of tubular prostates paired on adjacent segments, or paired on 17 or 19 separate or combined with a single pair of prostatic pores on the same segment (i.e., not united on 18 as in the Megascolecidae), sometimes pores midventral, (e.g. in *Lavellodrilus* Fragoso, 1988). Female pores on 14. Lumbricine (or sometimes perichaetine or anisochaetine, e.g. NZ's *Eudinodriloides* Lee, 1959: 72 and semi-balantine *Sylvodrilus* Lee, 1959: 181, respectively). **Holoic, vesiculate or avesiculate**. Oesophageal [and rarely intestinal e.g. in some *Lavellodrilus* by Fragoso, (1991)] gizzard(s) present (single or multiple), or rudimentary, or absent; calciferous glands commonly present but not arranged as in the Ocnerodrilidae, or absent. Spermathecae diverticulate or adiverticulate. Last hearts behind segment 11.

Taxonomic Notes: The enigmatic genus ***Hegesipyle*** Kinberg, 1867: 97, 101, (type *H. hanno* Kinberg, 1867: 101 from Durban, South Africa) possibly has overall priority in the family and although the name is still available it has fallen from use since it was listed as *Genus dubium* by Michaelsen (1900: 418). It is a valid name and may yet be resurrected.

New Caledonian *Acanthodrilus* Perrier, 1872; Neotropical/subantarctic *Microscolex* Rosa, 1887 (syn. *Notiodrilus* Michaelsen, 1899); Australian and New Zealand genera: *Rhododrilus* Beddard, 1889 (syns. *Leptodrilus*, *Kayarmacia*) and *Diplotrema* Spencer, 1900 (syn. *Eodrilus* Michaelsen, 1907) - all remain in the Acanthodrilidae. *Lavellodrilus* Fragoso, 1988 that differs by its midventral male and spermathecal pores, also belongs in Acanthodrilidae. Meso/North American

Diplocardia Garman 1888 is currently placed in Acanthodridae but the resurrection of Diplocardiidae Michaelsen, 1899 may be merited.

Some authors mistakenly attribute meroic West African *Millsonia* Beddard, 1984 (sometimes misspelt "*Milsonia*") and its sister taxon *Reginaldia* Csuzdi, 2006 (type *Millsonia ghanensis* Sims, 1965 with sub-genus *Peritogaster* type-species *Millsonia anomala* Omodeo, 1955) to Acanthodrilidae although it belongs in Octochaetidae as defined herein (or in subfamily Benhamiinae by Csuzdi, 1996: 360, 365).

Csuzdi & Zicsi (1994: 230) and Csuzdi (1996: 365) included the holoic genera *Pickfordia* Omodeo, 1958 and West African *Wegeneriella* Michaelsen, 1933 (non Amazonian *Wegeneriona* Cernosvitov, 1939) in their Octochaetidae subfamily Benhamiinae Michaelsen, 1895 [that they misdate as "1895" since it was originally Benhamiacea Michaelsen, 1895: 23 and later as Benhamini (Michaelsen, 1897: 25) then Benhaminae (Eisen, 1900: 208) – as reported in Michaelsen (1900: 330) where it was included in synonymy of his subsequent Trigastrinae Michaelsen, 1900: 330; see also Stephenson (1923: 469; 1930); Gates (1959: 256): Blakemore (2013)]; these taxa (except *Wegeneriona*) actually belong in Acanthodrilidae as redefined herein. Csuzdi (1996: 350-351) later redefined Acanthodrilidae to accept either the holoic (Acanthodrilinae s. Csuzdi) or meroic (Octochaetinae s. Michaelsen, 1900) states, but this was soon confounded by a rather contrived tribe 'Neogastrini' in Csuzdi (1996: 363) that allowed either state and is not accepted here. Consequently Csuzdi's 'Neogastrini' genera are re-allocated thus:

Neogaster Cernosvitov, 1934 from S. America - Octochaetidae;

Pickfordia (*Pickfordia*) Omodeo, 1958 from West Africa - Acanthodrilidae;

Pickfordia (*Omodeoscolex*) Csuzdi, 1993 from S. America [three taxa: *Notiodrilus divergens divergens* Cognetti, 1905 - misspelt "*Neogaster divergeus*" and claimed exotic by Fragoso *et al.* 1994: 78, 238; *divergens itapecu* and *tocaya* both by Righi *et al.*, 1978] with two West African species [*africana* and *cisatlantica* both by Omodeo, 1955 that were listed by Csuzdi (1993: 66) but were overlooked by Csuzdi (1996: 364) and they probably require re-investigation and possibly generic reallocation] - Acanthodrilidae;

Wegeneriella Michaelsen, 1933 from West Africa - Acanthodrilidae;

Wegeneriona Cernosvitov, 1939 from South America - Octochaetidae.

Futhermore, Csuzdi's (1996: 365) definition of a Gatesian Megascolecidae with only

racemose prostates separated from Acanthodrilidae s. Csuzdi with tubular prostates is superceded by the redefinitions by Blakemore (2000, 2013) as repeated herein (cf. Omodeo (2000: 188, 194) who makes a detailed report of the location of some of these "Neogastracea" genera but has very confused taxonomy, eg. claiming "Octochaetona *and* Hoplochaetina *have endemic species in India* ***and*** *New Zealand*", etc. etc.

Michaelsen (1910: 53) divided Acanthdrilidae into sectio Eodrilacea, Diplotremacea (= Eodrilacea), Neodrilacea, Acanthodrilacea, Maheinacea, Chilotacea and Howascolecea (this latter more properly in Octochaetidae); some of these may merit retention as sub-families under Blakemore's (2013) revision of world families.

The genera *Pontodrilus*, *Plutellus*, *Argilophilus*, *Megascolides* and *Diporochaeta* are now returned to Classical Megascolecidae rather than "*Acanthodilidae s. Gates*". [A taxonomic note on effects of suppression (or addition) of anterior segments on male pore location accompanies this family diagnosis below].

Distribution and diversity: A widespread primarily Gondwanan (or pre-Gondwanan, e.g. Pannotian?) family endemic throughout much of the southern hemisphere, in West and South Africa, Madagascar (e.g. *Hegesipyle sp. Acanthodrilus majungianus* and *A. voeltzkowi*), Central and South America, Australasia, New Caledonia, islands of the Southern Ocean (presumably including Antarctica in past geological times); also with (possibly more recent?) extensions into central and eastern North America – with possible extinctions from India although a single dubious species, *Diplocardia* (?) *indica* Stephenson, 1924, is reported. The family is well represented in New Zealand distributed on both North and South Islands although dominant in the south (Lee, 1959; 1994) where the endemic genus *Rhododrilus* is particularly common. *Acanthodrilus* Perrier, 1872 is from New Caledonia and *Microscolex* Rosa, 1887 originating from southern South America is now endemic throughout Southern Ocean.

Regarding the **absence from India and Asia of Acanthodrilidae**, this mystery may have been partly explained >60 years ago by Bahl (1947) when he talks of certain anatomical novelties (eg. enteronephry) and moisture conservation in monsoonal regions. Thus we may speculate that it is their adapatations to meronephry, as a means of water conservation, that has supplanted holoic Acanthodrilidae from these regions subjected to seasonal droughts and floods. Contrarywise, the native Acanthodrilidae in Australia are also subject to periodic and sometimes extended drought but yet seem to thrive, with only a few native Octochaedidae species

currently recognized there. Monsoons are more frequent and survivable than droughts.

Acanthodrilid *Diplotrema* from Australian and New Zealand [and possibly Malagasy from *D. dauphinianus* (Michaelsen, 1910) previously in *Eodrilus*] is phyletically an ancient genus (cf. the megascolecids *Pontodrilus* and *Plutellus*), that is closely related to genera found on Gondwanan fragments. A debatably similar genus is *Diplocardia* Garman, 1888, found in southeastern parts of North America including Florida that are though part of an exotic terrane of the future Gondwana that remained sutured to North America during the fragmentation of Pangea during the early Paleozoic (Opdyke *et al. Geology,* 1987: 900-903). [James (1990) provisionally placed two Mexican species in *Diplotrema*, viz. *D. murchiei* and *D. papillata*, but these and several other Mexican e.g. *Diplotrema oxcutzcabensis* (Pickford 1938), Belizean, Chilean, Argentinian (e.g. *Eodrilus. silvestrii* Rosa, 1891) and Brazilian earthworms (plus the Cuban *Acanthodrilus ulrici* Michaelsen, 1923) variously placed in *Diplotrema*, *Notiodrilus* and/or *Eodrilus* and more recently in *Kaxdrilus* Fragoso & Rojas, 1994, also require clarification and distinction from genus *Microscolex*]. The present day distribution of *Diplotrema* is restricted to northern Australia (i.e., Qld, NT, north-west WA and northern NSW), where species are found in rainforest, woodland, grassland, cultivated soils, and a few moisture retaining refugia in arid areas (Blakemore, 1994a; 1997b and in prep.), and New Zealand (Blakemore, 2004f, 2011). *Diplotrema* as reported from the Neotropical region [Mexico, El Salvador, Belize, Cuba, Guatemala by Fragoso *et al*. (1995: 111) require clarification, as noted above].

Currently about 1,000 Acanthodrilidae taxa are described (Csuzdi, 2003; Blakemore, 2005, 2006 and in press). A few species are widely distributed by transportation. Modes of transportation and initial introduction of exotics are by oceanic rafting of euryhaline (salt water tolerant) species, by carriage on birds' feet, or incidental to human migrations (Stephenson, 1930; Lee, 1959; 1985). The reports of some species in West Africa and South America may be due to recent human trade in either direction and, moreover, certain non-endemic species in Australia may predate the arrival of European settlers, reflecting earlier undocumented commerce with south-east Asia and Indo-Pacific Islands (Blakemore, 1999: 185; 2009).

The genus *Microscolex* originates from southern South America (Gates, 1972; Lee, 1968; 1994) while *Rhododrilus* is from New Zealand and (syn. *Kayarmacia*) from Australia. About seven exotic Acanthodriles are presently recorded for Australia (Blakemore, 1994a: 296-297; 1999; 2000; 2005), three of these also from Tasmania:

viz. *Rhododrilus kermadecensis* Benham, 1905, *Microscolex dubius* (Fletcher, 1887) and its sibling species *M. phosphoreus* (Dugès, 1837) - (these latter two new records by the current author were found in the drain of a carpark at Rocherlea, Tasmania), plus the probable neo-endemics *M. kerguelarum* (Grube, 1877) from Heard Island and *M. macquariensis* (Beddard, 1896) on Macquarie Island from whence it was recently re-sampled (Blakemore, 1998). These latter two species are closely related to congeners on other sub-Antarctic islands [such as *M. georgianus* (Michaelsen, 1888) that has two or three morphs varying in presence or absence of the posterior pair of prostates], and would have had to undergone speciation in the 11,000 years since the islands emerged or since last glaciation or possibly colonization is from other islands from which they have not yet been reported or that are now submerged.

Although *Microscolex dubius* was first described from Sydney, Mulwala (in soil brought from Melbourne), and Adelaide (Fletcher, 1887a: 381), the homeland of this genus is in South America and it is not endemic to Australasia.

The cosmopolitan genus *Pontodrilus* and widely-dispersed species formerly placed in the catch all genus *Plutellus* that were previously included by some authors in Acanthodrilidae, are both now returned to the Megascolecidae *s.* Blakemore, 2000.

Generic priority as listed in order of publication in the Family Acanthodrilidae

Holoic species with acanthodriline (including microscolecine/balantine) male pores:

1. ***Hegesipyle*** Kinberg, 1867: 97, 101, type *H. hanno* Kinberg, 1867: 101, from Durban South Africa with types in Stockholm (Nr. 1943); listed as *Genus dubium et species dubium* by Michaelsen (1900: 418) although he also notes that Perrier (1886: 876) moved *H. hanno* to *Acanthodrilus*, whereas he though it belonged in either *Notiodrilus* or *Chilota* sensu Michaelsen (1900); see also Michaelsen (1913: 400). [For *H. hanno* type Michaelsen (1899: 432) says: "*the only specimen left in jar Nr. 12 cannot be identified*"]. Genus named after a Thracian princess.
2. ***Mandane*** Kinberg, 1867: 97, 101, type *M. patagonica* Kinberg, 1867: 100, from Chile with types in Stockholm (Nr. 156); listed as junior homonym of *Mandane* Kinberg, 1865: 253 (Polychaeta), thus genus name unavailable; cf. *Chilota* Michaelsen, 1899.
3. ***Acanthodrilus*** Perrier, 1872 with type *A. ungulatus* Perrier, 1872 (syn. *A. layardi* Beddard, 1886); mainly from New Caledonia and adjacent islands; after Pickford (1937) shown to differ from other genera by its J-shaped nephridial vesicles, testis sacs, gizzard(s) and, at least typically, presence of penial setae with prostatic pores in 17 & 19.
4. ***Microscolex*** Rosa, 1887 (February), type *M. modestus* Rosa, 1887 (= *M. phosphoreus*) originating from South America/Southern Ocean, acanthodriline/microscolecine,

distinguished by its weak gizzard, presence of (non J-shaped) nephridial bladders, often a setal convergence around male pores (as first noted by Michaelsen, 1900), and erstwhile presence of penial setae.

5. ***Neodrilus*** Beddard, 1887: 157 from New Zealand, microscolecine with alternating nephridiopores and just 8 setae.
6. ***Photodrilus*** Giard, 1887 (November), same type as *Microscolex* therefore synonymous.
7. ***Diplocardia*** Garman, 1888 with type *D. communis* Garman, 1888, from eastern and southern USA into Baja California and Mexico, is avesiculate (like *Diplotrema* and *Notiodrilus*) and differs in having duplicated gizzards in two (or three) segments, albeit sometimes fused or united; James (1995: 33) misinforms there is but a single gizzard!
8. ***Rhododrilus*** Beddard, 1889 with type *R. minutus* Beddard, 1889 mainly New Zealand / Australia, differs from *Microscolex* by its more developed gizzard extending though one or two segments, secondarily its microscolecine reduction (male and prostatic pores in 17, as have some *Microscolex* spp.), 8 setae, nephridial bladders present or absent.
9. ***Plagiochaeta*** Benham, 1891/2 from New Zealand, acanthodriline with alternating nephridiopores and >8 setae.
10. ***Deltania*** Eisen, 1893, type *D. elegans* Eisen, 1893, supposedly same as *Microscolex* according to Michaelsen (1900: 139).
11. ***Geodrilus*** Ude, 1893, type *G. singularis* Ude, 1893, same as *Diplocardia* according to Michaelsen (1900: 324).
12. ***Aleodrilus*** Eisen, 1896, type *A. keyesi* Eisen, 1896, same as *Diplocardia* according to Michaelsen (1900: 324).
13. ***Maoridrilus*** Michaelsen, 1899: 234 with type *M. dissimilis* (Beddard, 1885), mainly from New Zealand, acanthodriline with alternating nephridiopores and just 8 setae.
14. ***Chilota*** Michaelsen, 1899: 237, type *Mandane littoralis* Kinberg, 1867: 100 (et *litoralis* = *Mandane patagonica* Kinberg, 1867, syn. *Chilota corralensis belgicae* Cernosvitov, 1934); note *Mandane picta* Michaelsen, 1889 recently restored as *C. picta* from synonymy by Csuzdi & Zicsi, 2001) from South America and Southern Ocean. Michaelsen (1900: 122) separated *Chilota* from *Yagansia* by its two pairs of prostates rather than one pair; it has large gizzard(s) in 5-6 and differs from *Parachilota* by its nephridial bladders. Recently reviwed by Zicsi (1993).
15. ***Maheina*** Michaelsen, 1899: 237, type *Acanthodrilus braueri* Michaelsen, 1897 (type in Hamburg, 7262) from Mahé, Seychelles; Michaelsen (1900: 122) separated it from *Chilota* and *Yagansia* by its metandry against their proandry; its gizzard is in 6. Beddard (1912: 78) thought it a possible senior synonym of *Notiodrilus* although Csuzdi (pers. comm. 13th May, 2008) says it is probably an Ocnerodrilidae!
16. ***Yagansia*** Michaelsen, 1899: 237, type *Cryptodrilus*? *spatulifer* Michaelsen, 1889 from South America; (Michaelsen (1900: 122) separated it from *Chilota* by its one pair of

prostates (and one pair of spermathecae), rather than two pairs typical of his other genus; its gizzard is in (5 or) 6. Recently reviwed by Zicsi (1989). [Cf. *Udeina*].

17. ***Notiodrilus*** Michaelsen, 1899: 239 with type *Acanthodrilus georgianus* Michaelsen, 1888, from Southern Ocean; Michaelsen (1900: 122) separated it from *Microscolex* and/or *Rhododrilus* by its two pairs of prostates, rather than a single pair typical of these other genera; but it was later found (by Michaelsen, 1905; and by Pickford, 1937) that this difference was unreliable, so *Notiodrilus* entered synonymy of *Microscolex*.
18. ***Diplotrema*** Spencer, 1900 with type *D. fragilis* Spencer, 1900 from Australia/N.Z. is distinguished by its lack of nephridial bladdders, its strong single gizzard, and typically the presence of penial setae and usually genital setae although these may also be absent (especially in N.Z. worms). Sweet (1900, fig. 6) first showed type to have two pairs of prostate glands. Species from other regions variously placed in *Diplotrema* and/or its junior synonym *Eodrilus* probably require re-evaluation.
19. ***Omahania*** Eisen, 1900, type *O. verrucosa* (Ude, 1895), subgenus same as *Diplocardia* according to Michaelsen (1900: 324).
20. ***Naillenia*** Eisen, 1900, type *N. koebeli* Eisen, 1900, subgenus same as *Diplocardia* according to Michaelsen (1900: 324).
21. ***Zapotecia*** Eisen, 1900: 165, type *Z. amecamecae* Eisen, 1900 from Mexico, has 3 discrete gizzards, otherwise similar to *Diplocardia*.
22. ***Dinodriloides*** Benham, 1904, type *D. beddardi* Benham; from New Zealand microscolecine, strong gizzard in 6, with 12 setae; nephridia vesiculate.
23. ***Eodrilus*** Michaelsen, 1907, type *E. cornigravei* Michaelsen, 1907 from Cannington, Western Australia; supposedly differed from *Diplotrema* by its acanthodriline male pores, and from *Notiodrilus* by the presence of genital setae near spermathecal pores, but since both these conditions are now known to characterize prior *Diplotrema*, it therefore entered synonymy.
24. ***Leptodrilus*** Benham, 1909, type *Rhodrodrilus leptomerus* Benham, 1905 (syn. *L. magneticus* Benham, 1909), same as *Rhododrilus* according to Lee (1959: 130).
25. ***Perieodrilus*** Michaelsen, 1910 from New Zealand, acanthodriline, lacking nephridial bladders and penial setae, with >8 setae.
26. ***Udeina*** Michaelsen, 1910, type *Yagansia kinbergi* Michaelsen, 1899 from South Africa; balantine with gizzard in 5 was, separated off from *Yagansia* from South America; its restoration from synonymy in *Parachilota* supported by Plisko (2004).
27. ***Wegeneriella*** Michaelsen, 1933 type *Notoscolex valdiviae* Michaelsen, 1903; from tropical west Africa, has a gizzard, unpaired spermathecal pores, 8 setae.
28. ***Parachilota*** Pickford, 1937, type *Chilota algoensis* Michaelsen, 1899, from S. Africa; balantine, nephridia without bladders, gizzard in 5-6.
29. ***Balanteodrilus*** Pickford, 1938, type *B. pearsei* Pickford, 1938 from Mexico and Belize.

30. ***Decachaetus*** Lee, 1959: 38 from New Zealand, acanthodriline with strong gizzard and 10 setae.
31. ***Eudinodriloides*** Lee, 1959: 72 from New Zealand acanthodriline, weak gizzard, with 12 setae, i.e., >8 setae per segment.
32. ***Neochaeta*** Lee, 1959: 232 from New Zealand, microscolecine with alternating nephridiopores and >8 setae.
33. ***Sylvodrilus*** Lee, 1959: 181 from New Zealand semi-balantine with nephridial vesicles and anisochaetine setae (8 in anterior rising to >8 in hind segments, i.e.non-lumbricine).
34. ***Pickfordia*** Omodeo, 1958, type *P. magnisetosa* Omodeo, 1958, from tropical west Africa and south America is lumbricine, lacking a gizzard, with (*Pickfordia*) or without (*Omodeoscolex* Csuzdi, 1993) spermathecal diverticula (possibly combinable?).
35. ***Lavellodrilus*** Fragoso, 1988 from Central America, avesiculate nephridia, with single oesophageal gizzard in 5 and (after Fragoso , 1991) rarely with intestinal gizzard in 15 too; male and spermathecal pores midventral.
36. ***Larsonidrilus*** James, 1993 from Mexico, gizzard in 5, nephridia avesiculate.
37. ***Protozapotecia*** James, 1993, type *P. aquilonalis* James, 1993 from Mexico; has 2 discrete gizzards rather than the 2 continuous gizzards of *Diplocardia*.
38. ***Kaxdrilus*** Fragoso & Rojas, 1994: 3 accommodates all species from central America with calciferous glands in region of 7-12 formerly placed in *Diplotrema*.
39. ***Mayadrilus*** Fragoso & Rojas, 1994: 8 from central America is metandric but otherwise supposedly like *Diplotrema* or *Lavellodrilus*.
40. ***Eodriloides*** Zicsi, 1998 (type *Acanthodrilus peringueyi* Michaelsen, 1913) for South African and Malagasian "Eodrilids" separated on the grounds that they have no nephridial bladders but two spermathecal diverticula [Csuzdi pers. comm. and from Zicsi (1998); although some Australian *Diplotrema* are claimed to have paired diverticula viz.: *Diplotrema bidiverticulata* and *Diplotrema cornutheca* both by Dyne, 2000 (in Jamieson, 2000). Thus *Eodriloides* is also in the ambit of *Diplotrema*].

Thus, in essence, key genera are:

1. ***Hegesipyle*** Kinberg, 1867: 97, 101, type *H. hanno* Kinberg, 1867: 101, from Durban South Africa, has overall priority but since it was listed as *Genus dubium* by Michaelsen (1900: 418) it has fallen from use; notwithstanding ICZN (1999: Art. 23.9 concerning disuse after 1899 for senior synonyms), this name is yet nomenclaturally available.
2. ***Acanthodrilus*** Perrier, 1872 takes next priority (see Horst, 1887), but, following Pickford (1937), is restricted to forms with J-shaped nephridial bladders.
3. ***Microscolex*** Rosa, 1887 (syns. *Photodrilus*, *Deltania*, *Notiodrilus*), the next available genus that differs from *Rhododrilus* and other genera under consideration by having a poorly developed gizzard (which may be more developed in *Notiodrilus* synonymic species) and nephridial bladders that, however, are non J-shaped.

4. ***Diplocardia*** Garman, 1888 (syns. *Geodrilus*, *Aleodrilus*, *Omahania*, *Naillenia*) is a North and Meso-American genus with doubled gizzards (in Diplocardi-inae/-idea?) that lacks nephridial bladders.
5. ***Rhododrilus*** Beddard, 1889 (syns. *Leptodrilus*, *Kayarmacia*) mainly from New Zealand has microscolecine reduction, and – tentatively separating it from *Microscolex*, a single well-developed gizzard; nephridial bladders may be present or absent.
6. ***Diplotrema*** Spencer, 1900 (syns. *Eodrilus* and possibly *Eodriloides*) from Australian/New Zealand has a single gizzard, calciferous glands are absent or present (intramurally) and it lacks nephridial bladders. Species from Central or South America and South Africa placed by some authors in either *Diplotrema* or in its junior synonym *Eodrilus*, require re-evaluation. There is nothing substantial to separate the type of *Eodrilus*, *E. cornigravei*, from synonymy in *Diplotrema*, therefore the genus name enters synonymy too and species without characteristics of '*Diplotrema*' must be moved. The genus name '*Eodrilus*' is no longer available but, as noted above, there are many possibilities and options for generic reallocation; pending resolution, at least temporarily these taxa may be placed under the earlier genus: *Microscolex*.

Michaelsen (1910: 52) provided a key to genera as then known. In a recent revision, Csuzdi (1997: 45) defined "*Eodrilus*" with acanthodriline or microscolecine male field, with or (significantly) without a gizzard, but lacking calciferous glands and nephridial bladders; however, this genus (by virtue of its type-species) is considered a junior synonym of Australasian *Diplotrema* and the South American species probably belong better in *Microscolex* or some other genus. In fact, Gates (1982: 16) had said "*Indeed, the author pointed out (Gates, 1967: 68) that Mexican species could go equally well into* Eodrilus *as defined by Michaeslen (1907) or by Pickford (1937) or into* Acanthodrilus *as defined by Stephenson (1930).*"

The following key for some Acanthodrilidae taxa, not all peregrine, is modified from Zicsi's (2003) South American key, followed by a keys to peregrine genera. Holoic nephridia either have or lack nephridial vesicles - also called "*nephridial bladders*":

Key to some common (mainly South American) acanthodrilid genera

1. Male organs not holandric (eg metandric with testes in 11 only) …… 2

   Male organs holandric (testes in both 10 & 11) ……. 4

2. Prostatic and spermathecal pores two pairs each …….…..... 3

   Prostatic and spermathecal pores one pair ….. *Yagansia* Michaelsen, 1899

3. Holoic with bladders ……..……. *Chilota* Michaelsen, 1899

Without bladders ……..…….. *Parachilota* Pickford, 1937

4. Holoic with bladders (not J-shaped as in *Acanthodrilus*) … *Microscolex* Rosa, 1887

Without bladders ……..… 5

5. Gizzard single in 5 or 6 .. *Diplotrema* Spencer, 1900 (syn. *Eodrilus* Michaelsen, 1907) from Australia and New Zealand (Mexican species put this genus are dubious)

Gizzard doubled in 5-6 or 6-7…… *Diplocardia* Garman, 1888

Gizzard trebled in 5-7……. *Zapotecia* Eisen, 1900

<u>Key to Peregrine Acanthodrilidae (and Diplocardi-inae/-idae) genera</u>

1. Gizzard in single segment or absent (nephridial bladders present or absent) …. 2

Gizzards duplicated in 5-6 or 6-7 (nephridial bladders absent) ... *Diplocardia**

2. Single gizzard often well developed …….……..….. *Rhododrilus*

Gizzard weak or absent ……..……... 3

3. Nephridal vesicles present, calciferous glands absent; male and prostatic pores on 17; spermathecal pores, when present, in (7/8 or) 8/9……..... *Microscolex/Yagansia***

Nephridial vesicles absent, calciferous glands present (in 14-15) …….. 4

4. Spermathecae with diverticula ..... *Pickfordia* (*Pickfordia*)***

Spermathecae without diverticula ..... *Pickfordia* (*Omodeoscolex*)***

* It is possible that North/Meso-American *Diplocardia* and any related genera belong to the resurrected higher taxon Diplocardiinae/-idea rather than Acanthodrilidae. *Diplocardia eiseni* (Michaelsen, 1894) is considered exotic in Mexico and *D. singularis* (Ude, 1893) reported from Colombia may be an introduced species as this is outside the normal generic range – both are diagnosed below.

** *Yagansia* (cf. *Microscolex*) from Central/S. America has single paired prostates (and spermathecae) and gizzard in 5 or 6; *Y. longiseta* (Beddard, 1895: 229) [syn *Y. papillosa* (Beddard, 1895: 230)] is possibly peregrine with unconfirmed and probably mistaken report in N. America and Africa. Note: Chilean *Acanthodrilus corralensis* Beddard 1895: 222 is now in *Chilota* while *Microscolex corralensis* Beddard 1895: 235 is in *Yagansia*.

*** *Pickfordia* has an "amphiatlantic" distribution with subgenera endemic to West Africa alone (*Pickfordia*) or to both West Africa and S. America (*Omodeoscolex*). Two taxa with widespread distributions in Central and South America that may be indicative of transportation are *Pickfordia* (*Omodeoscolex*) *divergens divergens* (Cognetti, 1905) reported from Panama and Equador, and *P.* (*O.*) *divergens*

itapecu (Righi, *et al.*, 1978) known from Gaudeloupe Island (Caribbean), Brazil and Paraguay. Two species in this sub-genus (*africana* and *cisatlantica* both by Omodeo, 1955) are also reported from W. Africa, possibly by transportation.

Genus ***Diplocardia*** Garman, 1888

Diplocardia Garman, 1888: 47; Eisen 1899 (fig.); 1900 (figs.); Michaelsen, 1900: 324 [syns. *Geodrilus* (type *G. singularis*), *Aleodrilus* (type *A. keyesi*), *Omahania* (type *O. verrucusa*), *Naillenia* (type *N. koebeli*)]; Gates (1943; 1958: 3, 1982: 30); Murchie (1958: 270; 1961: 367; 1966: 609; 1967: 111; Fender & McKey-Fender (1990: 360).

Type-species: *Diplocardia communis communis* Garman, 1888: 47 from Illinois (Urbana, Champaign).

Diagnosis: Lumbricine. Avesiculate holoic. Acanthodriline male field with tubular prostates. Male pores single pair opening somewhere in 18-22. Gizzards, doubled in 5-6 or 6-7. Extramural calciferous glands absent (oesophagal folds sometimes present and Gates, 1982: 30 says "*Ten species, at least, have calciferous lamellae in segments xiv-xv. ... An eleventh species (*D. bivesiculata*) has the lamellae in xv-xvii*"). Intestine origin from 14-20. Dorsal vessel single or doubled. Holandric, testis sacs absent. Penial setae present; genital setae often present. Nephridial bladders absent. In semi-aquatic habitats, but also from farmland and forest. Haploid chromosomes = 22.

Taxonomic Notes: The genus *Diplocardia* is defined by its duplicated gizzards, in this regard, James (1995: 33) was quite mistaken to claim that it has but a single gizzard, as in *Diplotrema*, albeit in more than one segment, when he said:

"Diplocardia *is closely related to the other acanthodriline genera* Notiodrilus *and* Diplorema*, in that all have avesiculate holonephridia and the acanthodriline arrangement of male genitalia.* Diplocardia *differs in having* ***a gizzard*** *extending through two segments rather than one. The* Diplocardia ***gizzard*** *appears as one unit with little or no dividing line at the insertion of the septum 5/6, which septum is thin and membranous.*" [My **bolding**].

In actuality, *Diplocardia* as defined by Michaelsen (1900: 324) has duplication to give ***two gizzards in some of 5-7*** (cf. three in *Zapotecia* Eisen, 1900) not one! [See also: Eisen (1899); Gates (1943; 1958: 3); Murchie (1958:

270; 1961: 367; 1966: 609; 1967: 111) "*gizzards in V, VI*" cf. Murchie (1956: 210); James (1988: 303 – "*2 gizzards*"; 1990: 180 – "*gizzards in v, vi*"; 1994: 623, 625, 627 – "*two gizzards in v, vi*"); Fender & McKey-Fender (1990: 360), on *Argilophilus* say its gizzard is "*not double as in* Diplocardia"; and finally Csuzdi & Szlavecz (2002: 46) : *Diplocardia* has "*Two oesophageal gizzards fused in 5-6*"].

Distribution: USA except absent from the northwestern USA (distributed from Southern California east through the central plains of Nebraska, Ohio, Indiana, Illinois and Missouri to southern Pennsylvania and south to Delaware and Tennessee down to southern Florida and Texas) with a few species in Baja California and Mexico proper, e.g. *D. alba mexicana* Gates, 1955 (redescribed by Murchie, 1967: 116, fig. 2). A Mexican report of *Diplocardia eiseni* (Michaelsen 1894: 184) (originally *Geodrilus eiseni* Michaelsen, 1894: 184) from "*Arteaga 1992*" was considered by Fragoso, (2001) as an exotic there; it was originally described from a homeland in Florida and Georgia (Michaelsen, 1900: 328). Part of a *D. singularis* species-complex is reported (introduced?) in Colombian Andes [Feijoo *et al*. (2004)]. A single dubious species, *Diplocardia* (?) *indica* Stephenson, 1924: 353 and Stephenson (1930: 850), comes from Buldana, Berar, Maharashtra, India. Sporadic reports of *Diplocardia* from feedlots in New Mexico and Arizona (Gates, 1967) may represent translocated natives.

Remarks: *Diplocardia* species are used commercially as fishing bait in the USA and one method of collection is by 'grunting' – using vibrations from sticks to emulate predatory American moles (*Scalopus aquaticus*) causing the worms to exit from the soil (Eisen, 1900: 247; Catania, 2008; Mitra *et al.*, 2008). In Florida the two most common species extracted are *D. mississippiensis* and *D. floridiana*, both by F. Smith, (1924) whereas *D. riparia* F. Smith, 1895 [?syn. *Diplocardia prosenteris* Macnab & McKey-Fender, 1955] is more common in the Western States and its occurrence in Minesota may be by introduction (Ref.) - these, and similar species, are thus subject to transportation and likely translocation (Vail, 1972; Brower, 1999).

Csuzdi & Slavecz (2003) report: "*Eisen (1900) had already suggested that palearctic earthworm species were replacing the native North American fauna. Smith (1928) surveyed earthworms in Illinois for 30 years. He found that both the diversity and the abundance of introduced earthworms increased and correspondingly the abundance of indigenous species decreased dramatically. For example* Diplocardia communis *Garman, 1888 was one of the most common endemic earthworm species in*

the Champaign-Urbana region and by 1927 it was almost completely replaced by European Lumbricus terrestris *L.*"

Diplocardia eiseni (Michaelsen, 1894)

Fig. after Murchie (1967: 111, fig. 1).

Geodrilus eiseni Michaelsen, 1894: 184. [From Florida. Types Stokholm, 152]. [Non *Eodrilus eiseni* Michaelsen, 1911 (= *Acanthodrilus*)].

Diplocardia eiseni : Smith, 1895: 148; Ude, 1895: 136; Eisen, 1900: 173; Michaelsen, 1900: 238; Gates, 1943; Murchie, 1967: 111, fig. 1.

Distribution: Florida (Orange County), Georgia (Savanna), South Carolina, Texas; and possibly exotic to Mexico [Fragoso (2001)]. [Cf. *Eutrigaster* (*Graffia*) *eiseni* Csuzdi & Zicsi, 1991: 188 also from Mexico that is sometimes miscited as "*Diplotrema eiseni*". Note subgenus *Graffia* praeocc. is now *Graffiona* Csuzdi, 2014 moreover this taxon now transferred as *Dichogaster eiseni* (Csuzdi & Zicsi, 1991)].

Diagnosis: 30-160 mm by 1.5-3.5 mm. Segments 123-165. Colour unpigmented or grey. Prostomium epilobous. Dorsal pores after 11/12. Setae lumbricine 2ab=bc>cd. Spermathecal pores two, rarely three pairs in (6/7),7/8-8/9. Genital setae present on pads in 8 and 9. Female pores on 14. Male pores 19 in a lines, prostatic pores 18 and 20 in b lines at ends of seminal grooves. Long penial setae present, unornamented. Clitellum annular 13-18. Genital pads in 18-20. Gizzards in 5 and 6. Intestine from 18. Dorsal blood vessel doubled and last hearts paired in 13. Holoic, pores exit near d setae. Holandric with seminal vesicles paired in 9 and 12. Prostates tubular. Spermathecal sac with short diverticulum.

Notes: *Diplocardia bivesiculata* Murchie, 1961 is a similar species from Florida.

Diplocardia singularis (Ude, 1893)

Geodrilus singularis Ude, 1893: 69, fig. 16-19. [From Danville, Kentucky. Types Berlin 7414].

Diplocardia communis singularis ; Michaelsen, 1900: 326.

Diplocardia singularis ; Eisen, 1899: 170; Olsen, 1936; Gates, 1943; Murchie, 1967.

Distribution: Illinois (type-locality Danville, Urbana and Havana), Ohio, Missouri

(Olsen; 1933, 1936); N. and S. Carolina (Raleigh), Tennessee; introduced to Bogota, Colombia [Feijoo *et al*. (2004)].

Diagnosis: 54-120 mm by 3 mm. Segments 90-129. Colour flesh or gold-brown. Prostomium epilobous. Dorsal pores after 7/8. Setae lumbricine aa>bc, cd>ab<bc. Spermathecal pores three pairs in 6/7-8/9. Female pores on 14 median to a setae. Male pores 19, prostatic pores 18 and 20 at ends of seminal grooves. Long penial setae present. Clitellum mostly annular 14-½17 (13-18 in *D. c. communis*). Genital papillae paired in (13), 17 and 20 (21-22). Gizzards in 5 and 6. Intestine from 17. Dorsal vessel single, hearts paired in 10-13. Holoic, pores exit near d setae. Testis in 10 and 11, seminal vesicles in paired anteriorly in 9 and posteriorly in 12. Prostates tubular. Spermathecae sac-like each with narrowing duct and oblong diverticulum.

Notes: Sometimes misspelt "*Diplocardia singulares*" by Feijoo *et al.* (2004) who fail to give its subspecies. Subspecies *D. singularis caroliniana* Eisen, 1899 was said to differ on its penial setae ornamentation; it is possibly a junior synonym; then again, *D. singularis* differs from *D. communis* only on supposed differences of penial setae and these are now known (e.g. Blakemore, 1994; 2000) to be doubtful characteristics. Whereas *Diplocardia egglestoni* Murchie, 1958: 270; 1967: 119 from Michigan [erroneously listed as "*D. s. egglestoni* (Murchie 1958)" by James (1995: 36) - braces only needed if genus changes] is a parthenogenetic form lacking prostates that may belong in synonymy (as may *D. ornata* Gates, 1943: 113 that too differs only on penial setae). Such *Diplocardia* species groups are perhaps overdue for review (cf. Gates, 1943; Murchie, 1967: 119).

Genus ***Microscolex*** Rosa, 1887

Microscolex Rosa, 1887: 1; Michaelsen, 1900: 139 (syn. *Photodrilus, Deltania*); Eisen, 1900: 151; Michaelsen (1905) (syn. *Notiodrilus*); Pickford, 1932 (syn. *Notiodrilus*); Pickford, 1937: 424; Zicsi, 2004: 118. [Syns. *Photodrilus* Giardin, 1887 (type *M. phosphoreus*); *Allurus* (part.): Vaillant, 1889: 115; *Deltania* Eisen, 1893: 250 [type *D. elegans* (?= *M. dubius* or *phosphoreus*)]; *Pontodrilus* (part.): Beddard, 1895: 468; ?*Notiodrilus* Michaelsen, 1899: 239 (type *N. georgianus* Michaelsen, 1888)].

Type-species: *Microscolex modestus* Rosa, 1887 (= *L. phosphoreus* Dugès, 1837).

Diagnosis: Setae 8 per segment (often with setae a and b converging in the vicinity of

male pores). Male pores on 17 or 18, prostatic pores paired on 17 or 17 and 19 (i.e., microscolecine or acanthodriline); prostates tubular, penial setae usually present. Digestive system without a well developed gizzard nor calciferous glands. Nephridia holoic, vesiculate (but without the J-shaped bladders of *Acanthodrilus*).

Distribution: Circum-antarctic, origin in southern southern South America. *Yagansia* Michaelsen, 1899 is a closely related genus endemic to Central/South America. *Microscolex hyalochaeta* Michalsen, 1907 (sic but sometimes spelt "*hyalchaeta*") from Madagascar was transferred to *Notiodrilus* but probably requires reallocation. Two species, *M. dubius* and *M. phosphoreus*, are distributed worldwide by transportation and Gates (1972: 11, 37) thought that these two, plus *M. luisae* (Michaelsen, 1899: 99) that is supposedly endemic to a small coastal section of the South African Cape, may actually be parthenogenetic morphs segregated from a common ancestral interbreeding population, with *M. luisae* closer to the biparental morphology. Falkland Islands/South Georgia have these taxa: *Microscolex anderssoni* Michaelsen, 1905, *M. aquarumdulcium* (Beddard, 1893), *M. falclandicus* (Beddard, 1893), *M. georgianus georgianus* (Michaelsen, 1889), and *M. bovei* (Rosa, 1889) (that is also known from Buenos Aires and Puntas Arenas (Michaelsen, 1916: 9), [plus *Chilota dalei* (Beddard, 1890) from the Falklands group]. [**NOTE:** 1895 types of *Notiodrilus bovei* and *Notiodrilus fermani* from the Stockholm Museum were dumped with the GD collection to ANIC as curated by RJB in 1995 – see Blakemore (2005, 2006)]. In North and Central America other taxa have widespread distributions, e.g. a complex of *Microscolex benhami* (Eisen, 1893) from Almeda County, California and *Microscolex hempeli* Smith, 1896 from Florida, North Carolina and California (both thought to be synonyms of *M. phosphoreus*), and *Microscolex troyeri* (Eisen, 1893) found in California, Baja California, and continental Mexico (and possibly a further synonym of *M. phosphoreus*). From Australian territories, two other species are recorded: *Microscolex macquariensis* (Beddard, 1896) confined to Macquarie Island, and *M. kerguelarum* (Grube, 1877) [regarded as a senior synonym of *Acanthodrilus kerguelenensis* Lankester, 1879 by Lee, 1965, that itself is senior synonym of *A. kerguelensis* Michaelsen, 1891 according to Michaelsen (1900: 130) that appears to have been overlooked by Reynolds & Cook (1976)] from Kerguelen and from Australian volcanic Heard Island.

A "*fluorescent*" species recently named as *Microscolex wuxiensis* Xu *et al.* 1990 from China is probably *M. phosphoreus* as Acanthodrilidae are not native to the Orient.

Notes: If *Notiodrilus* is included in synonymy then the generic definition allows a

gizzard. Michaelsen (1905; 1911) argued that *Microscolex* originated in South America and its circum-antarctic distribution was largely due to oceanic transportation on prevailing (east to west) currents. Southern S. America appears to have a greater concentration of *Microscolex* species, many with euryhaline habitats and wide distribution supporting such an argument. More recent transportations, especially of parthenogenetic morphs, are more likely by human agency.

Key to widely distributed *Microscolex* commonly found outside South America

Spermathecae absent; non-luminescent; >50 mm ..... *Microscolex dubius*

Spermathecae present paired in 8/9; luminescent; <50 mm ... *Microscolex phosphoreus*

Microscolex dubius (Fletcher, 1887)

Fig. 1.12 *Microscolex dubius*, from Mundubbera, Qld., (a) ventral view, (b) prostate to male pore.

[?*Lumbricus dissidens* Weyenberg, 1879: 215. From Argentina. Types unknown – Michaelsen, 1900: 418 considered this a *species dubius* although he also thought it could be in *Microscolex*. Beddard said only that the clitellum was on 15-18 (Ref). Without types, its restoration is imprudent, also ICZN (1999: Art. 23.9) concerns disuse after 1899 for senior synonyms].

Microscolex modestus Rosa, 1887: 1 (part., balance = *M. phosphoreus*). [Also given as "Rosa, 1888: 4" but actually published four months before Fletcher's paper. Types unknown. Note: Rosa (1888) and Smith (1876: 117) claims Rosa's paper (20 Feb., 1887) preceeds Fletcher's (29 June, 1887), but as *modestus* is synonymized with *phosphoreus* this does not adversely effect *dubius* priority]; Rosa, 1891: 388 [Vienna Museum material from Cagliari, Sardinia].

Eudrilus(?) dubius Fletcher, 1887a: 378. [Sometimes misdated "*1886*". Type-Localities, Sydney, Mulwala, NSW ("*from a garden to which plants had been brought from Melbourne*"); Adelaide S.A. ("*possibly introduced*"). Types none.].

Microscolex dubius: Rosa, 1891: 388 [From Argentine. Note: Rosa notes that his *modestus* is separate from but succeeds Fletcher's *dubius*].

Microscolex poultoni Beddard, 1892: 32. [From Algeria/Tunis. Types missing].

Deltania elegans Eisen, 1893: 251; 1894. [From San Francisco. Types in Paris (AE 679)

and Berlin]. [Beddard (1895: 466) quotes spermathecae adiverticulate (? = *M. phosphoreus*)].

Deltania dubia: Eisen, 1894: 22.

Microscolex carolinae Eisen, 1900: 154. [Types?].

Microscolex dubius: Rosa, 1890: 511; Michaelsen, 1900: 140 (syn. *modestus* (part), *carolinae*, *elegans*?, *poultoni*?); 1907a: 146-7 (syn. *modestus, Poultoni, elegans, carolina*); Gates, 1954; 1967; 1972: 34, 1982: 30 (syn. *elegans*).

Distribution: Circummundane in warmer regions of the world: Australia, Norfolk Island, Tasmania, New Zealand [although Lee (1959: 179) said that Smith's (1893) record was doubtful as his specimen sent to the British Museum was found by Lee to be *Eodrilus palidus* and he knew of no other record from NZ], USA, South America, South Africa, Madeira Isls., also reported from the Canaries [June, 2006] as *Microscolex poultoni* Beddard, 1892 (but misspelt as "*poulteni*"); from Spain (e.g. Monroy *et al.*, 2003), Mediterranean Europe, e.g. Greece in Ref. (2015) and Jordan (Csuzdi & Pavlicek, 2005: 71); the Smithsonian has a specimen from Israel (http://collections.nmnh.si.edu/search/iz/?irn=731709). The supposed home of this peregrine species is in southern S. America (Gates, 1972). Previously reported from Norfolk Island, Sydney and Paramatta, NSW, (e.g. Fletcher, 1887; Michaelsen, 1907a), Cotter Dam Canberra, ACT, Vict., SA, Qld and WA (see Gates, 1954: 243; Blakemore, 1999). The current reports are new records for Qld, NSW, and Tasmania although Michaelsen (1900) without further information, reports this species from Tasmania. Lake Biwa, Japan is another **New Record** for Asia by RJB in 2011 [see Blakemore, 2012 – Japanese earthworms revisited a decade on (Oligochaeta: Megadrilacea). – *Zoology in the Middle East*, Supplementum 4: 15-22. http://www.kasparek-verlag.de/abstract].

Locality: Mundubbera, Qld; Budderoo Plateau, NSW; Rocherlea, Tasmania; Biwa Japan.

Habitats: Abundant below surface of moist soils; from drain of a carpark at Rocherlea.

Registration Nos.: Several specimens collected by the author. Lake Biwa specimens from drain next to bus stop in middle of paddy fields at Kusatsu Shiga-ken JET-156 and JET-157, in Tokyo Museum An-479 and An-480 collected by RJB 9th August, 2010 (**new record Japan and Asia**). Also from paddy drain on walk from Kataoka Ikishira Shrine to the LBM museum, 18/III/2011 by RJB – single specimen in LBM collection.

Behaviour: Docile when handled, luminescence not exhibited (cf. *M. phosphoreus*).

Length: 65-75 mm (cf. Gates, 35-90).

Width: 3-4 mm.

Segments: 100-115, setal lines visible.

Colour: In life, body pale with yellow clitellum.

Prostomium: Open epilobous.

First dorsal pore: None found.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment from 2, evenly spaced ventrally, b setae converge immediately adjacent to male pores, c and d are wider than ab (lateral nephropores that weaken body wall may also be mistaken for a 'fifth setal row'; setae on 17 modified as large penial setae (in position of setae a?); (5:3:5:3:22:0.3).

Nephropores: Near anterior furrow of each segment from 5 median to c lines laterally.

Clitellum: Annular, 13-$^{2}/_{3}$17(sometimes constricted on preservation?).

Male pores: On 17, in raised circular porophores in ab, with enlarged penial setae just median to male pores.

Female pores: Pair anterior to setae a in 14.

Spermathecal pores: Absent.

Genital markings: None.

Septa: 6/7-13/14 all thick.

Dorsal blood vessel: Single.

Hearts: Last heart 12 (also in 9-11).

Gizzard: Not developed (or small and weak in 5).

Calciferous glands: None.

Intestine origin (caeca, typhlosole): Oesophagus to 13, intestine widens from 16 and reaches full width by 18.

Nephridia: Pair of large holonephridia, with ocarina-shaped bladders, per segment.

Male organs: Testes/funnels in 10 and 11 in sacs, seminal vesicles in 10, 11 and 12.

Ovaries: Folded-fan-shaped strings in 13.

Prostates: A single pair in 17, tubular, smallish and bent into L-shape, ducts short.

Spermathecae: None [cf *Deltania elegans* has irregular spermathecae (Eisen, 1894)].

Gut contents: Void in specimens inspected.

Notes: Fletcher and Gates reported seminal vesicles in only 11 and 12.

Remarks: The possibility that *M. dubius* (and *M. beddardii* Rosa, 1895) may be athecal morphs of *M. phosphoreus* [and/or *M. luisae* (Michaelsen, 1899)] was proposed by Gates (1972), but is not supported here because of the differences in anatomy and behaviour and lack of substantial morphological/genetic evidence for such a merger.

Microscolex phosphoreus (Dugès, 1837)

Fig. 1.13 *Microscolex phosphoreus*, from Samford and Narayen research farms, (a) ventral view (Samford), (b) prostate, (c) spermatheca, (d) prostomium; (h) ventral view (Narayen), (g) prostate and penial setae and (f) spermatheca.

Lumbricus phosphoreus Dugès, 1837: 17, 24. [Type locality greenhouses Jardin des Plantes, Montpellier, France. Types none].

Lumbricus phosphoreus: Johnston, 1865: 62 (reports from Cork in 1843 of finding these in the bogs in the south of Ireland and Connaught; possibly also found near Liverpool, UK in 1853).

Microscolex modestus Rosa, 1887: 1. [Type locality Adelaide. Types? Cf. *M. dubius*].

Photodrilus phosphoreus: Giard, 1887: 872.

Microscolex modestus: Rosa, 1888: 4 (part, balance = *M. dubius*); Michaelsen, 1899: 216.

Microscolex algeriensis Beddard, 1892: 29. [From Algeria. Types?].

Deltania Troyeri Eisen, 1893: 251 (sic). [From Golden Gate, San Francisco. Types Berlin 2366]; Eisen, 1894; 1900; Michaelsen, 1900: 141 (syn. *Deltania t. var. crassa* + *lagunae* Eisen, 1896).

?*Deltania elegans* Eisen, 1893: 251; 1894. [From San Francisco. Types in Paris and Berlin; with adiverticulate/irregular spermathecae (Beddard, 1895: 466)].

Deltania Benhami Eisen, 1893: 252. [From Almeda, California. Types Berlin 2365]. ; Eisen, 1894; 1900 [= *Microscolex benhami*. Sometimes mistakenly attributed to Beddard (1895)].

Microscolex nova zelandiae Beddard, 1894: 33, fig. 1 (corr. *novaezelandiae*), [From New Zealand. Types BMNH 1904:10:5:495-500]. [Name sometimes misspelt "*novaeze**a**landiae*" and dated "1895"; Non *Acanthodrilus novaezelandicae* Beddard, 1885].

Eudrilus ? *dubius* (part?): Smith, 1894: 117.

Pontodrilus phosphoreus : Beddard, 1895: 472 [lapsus].

Deltania Troyeri var. crassa + *lagunae* Eisen, 1896: 169, 170 + 142, 147. [Types?].

Microscolex Hempelii Smith, 1896: 407, fig. 13 (sic). [From North America. Types in USNM].

Microscolex Benhami + *Microscolex parvus* + *M. parvus* var. *carolinianus* + *M. Horsti* Eisen, 1900: 152-160. [From USA and (*horsti*) introduced from Hawaii.

Types mostly missing].

Microscolex phosphoreus, Michaelsen, 1900: 141 (syn. *modestus*, ?*algeriensis*); 1907a: 148 (syn. *modestus, algeriensis, troyeri, novaezelandiae, benhami, crassa, lagunae, hempelii, horstii* (laps. pro *horsti*), *benhami, parvus, parvus carolinianus*); Stephenson, 1914: 388; Pickford, 1937: 433; Lee, 1959: 103 (syn. *novaezelandiae*); Gates, 1972: 35, 1982: 31 (syns. *troyeri, benhami, hempeli, carolinae, parvus, carolinianus, "phosphoreux"*).

?*Microscolex wuxiensis* Xu *et al.*, in in Xu, Zhang and Yang, 1990: 28. From Jiangsu, Wuxi. Types?] [Authors' described it as "*a new fluorescent earthworm from China*", no further information could be obtained, but it is a probable new synonym]. **Syn. nov.?**

Distribution: Cosmopolitan, eg. Ireland (Johnston, 1865 : 62 from boggy ground in the south of Ireland plus "*The Rev. F.B. Clarke had also found these annelids in the bogs of Connaught (Trans. Brit. Assoc. 1843, p. 76)*"; cf. Cotton, 1992 who mistakenly claimed its first Irish record!); Beddard (Nature, 1899: 52) reports it from England (Worcester); Sims & Gerard (1985, 1999: 140) list British records as "*Market gardens in Nottinghamshire (Friend, 1913a: 24), Jersey and Worcestershitre (Beddard, 1899: 52, Friend, 1913b: 459) also under compost, Dublin*"; Southern Europe [e.g. France, Italy, Yugoslavia, Greece in Gates (1982) and Ref., 2015], Asia [including Japan (Easton, 1981) and from Hawaian interception to Japan in earth around roots of *Chaenomeles* sp. on 23 Jan., 1957 (Gates, 1982: 31)], India, Pakistan, Turkey, Middle East (e.g. Israel Gates, 1972: 36; claim from Algeria by Baha, 1997), Americas (e.g. records of *Microscolex benhami* from USA), Hawaii (Righi, 1979: 112), Africa, New Zealand, Australia (Rosa, 1887 – a surprisingly early record considering South America was influential in World trade only after 1500's and Australian only after the First Fleet in 1787 even though this detoured via Rio di Janiero and Capetown; and Adelaide was settled after 1836). Michaelsen (1907a) also found this species in swampy soil at Cannington (Perth, WA) along with his natives: *Eodrilus cornigravei* and *Plutellus levi*.

New records from current studies are in Qld, ACT, NSW, Vict. and Tasmania plus confirmation from Japan (Lake Biwa) – collected 18/III/2011 from drain at Kataoka ast bus stop opposite paddy by RJB (two spex in LBM collection).

This species is probably indigenous to southern South America (Gates, 1972), e.g. being recorded from Magellan straits: Elizabeth island; Valparaiso: El Salto (Beddard 1896: 47).

Stephenson (1930: 644) cites a medical report from a fistula.

Locality: Narayen, Brisbane, Samford, in Qld; Scullin and Kippax, ACT; Cowra, NSW in pitfall trap; Rutherglen, Vict. Rocherlea and Melaleuca, Tasmania - new records for Australia. Lake Biwa Japan, another new record within Japan.

Habitat: Clay pasture soil under irrigated plots, glasshouse pots, riverbanks, suburban gardens, drain of a carpark at Rocherlea and beside road in Lake Biwa. Reported as abundant 230m down in coal-mines in Cracow (Krakow), Poland [http://www.biolbull.org/cgi/reprint/54/2/191.pdf].

Registration No.: QVM 14:0018, 14:0036 eight specimens from Tasmania "*Melaleuca D. King garden*"; seven specimens (author's collection): "*Rocherlea car park 8.vi.1996 Coll. RJB*".

Behaviour: Sluggish, exudes bioluminescent fluid from dorsal pores when agitated - luminescence elucidated by mechanical irritation visible to dark adapted eye.

Length: 33-42 mm (cf. Gates, 10-25, or 10-35).

Width: 1-1.5 mm.

Segments: 75-81 (cf. Gates, 36-90).

Colour: Colourless almost ghostly, setal lines visible, clitellum cream to buff.

Prostomium: Closed or open epilobous.

First dorsal pore: Lacking or unclear in one Samford specimen but apparent from 10/11 [Gates (1982: 32-33) says they may be present from 17/18 or a few levels before or behind the clitellum].

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment from second segment, fairly evenly spaced, but widening posteriorly, setae a and b on 17 modified as penial setae (seen in some specimens); (2:1:3:1:10:0.5).

Nephropores: Obvious, near anterior furrow of each segment (in 2-4 in d lines) from 4/5 slightly median to c lines.

Clitellum: 12,13-½17,17, setae and furrows retained.

Male pores: Equatorial on 17, (possibly in a small longitudinal furrow) in pair of small raised circular paps which encompass (modified?) setae ab; or unrecognizable.

Female pores: Pair just antero-median to a in 14.

Spermathecal pores: One pair in setal a lines in 8/9.

Genital markings: Large central translucent depression centred in 17/18 and smaller pad posterior of 17, (a Samford specimen had a circular genital marking presetally on 18lhs); sometimes also present in 10-18 and paired or median (Gates, 1982: 32).

Septa: 5/6-11/12 weak, 12/13-15/16 membranous.

Dorsal blood vessel: Single.

Hearts: Last heart 12 (also in 9,10-11).

Gizzard: Very small and weak in 5.

Calciferous glands: None although oesophageal dilations noted in 9,10-13,14.

Intestine origin (caeca, typhlosole): Oesophagus to 15, intestine widens from 16 or 17 (acacate, atyphlosolate).

Nephridia: Holoic: a pair of very large vesiculate (ocarina-shaped bladders) per segment.

Male organs: Testes/funnels iridescent free in 10 and 11; acinous seminal vesicles in 11 and 12.

Ovaries: Compact, palmate in 13.

Prostates: A single pair in 17, short and tubular, ducts thin and shorter than gland, a pair of penial setal sheaths sometimes obvious near ectal end.

Spermathecae: In 9, small pear shaped ampulla with two (occasionally only one or irregular, e.g. *elegans*) iridescent diverticula opposed on short duct opening in setal a line.

Gut contents: Soil and organic matter.

Cocoons: 5+ mm long with appendages ca. 3 mm long (= 5+) by 2 mm (Gates, 1982).

Notes: Opalescent glandular masses surround pharynx/oesophagus in 4-6. The luminescence is believed to be produced either by symbioitic bacteria or by luciferin-luciferase reactions (Gates, 1972).

Remarks: Gates considered *Microscolex* a "*congeries of parthenogenic morphs*" and suggested *M. luisae* (Michaelsen, 1899) could be a quadriprostatic morph ancestral to *M. phosphoreus* and/or *M. dubius*. An intermediate stage may resemble bithecate *M. collislupi* Michaelsen, 1910 from Argentina with prostatic pores paired in 17 connecting via a seminal groove to the male pores in 18. Although it retains its spermathecae, degradation of male terminalia is sometimes more defined in *M. phosphoreus* than in *M. dubius*.

Genus ***Rhododrilus*** Beddard, 1889

Rhodrodrilus Beddard, 1889: 380; Michaelsen, 1900; Stephenson, 1930; Lee, 1959: 130 (syn. *Leptodrilus* Benham, 1909: 276); Blakemore, 2004: 175 (syn. *Kayarmacia* Jamieson, 2000); Blakemore, 2007, 2010.

Type-species: *Rhododrilus minutus* Beddard, 1889 from NZ.

Diagnosis: Setae 8 per segment. One pair of male and prostatic pores on 17, usually separate but sometimes combined. Prostates tubular, penial setae usually present. Nephridia holoic, with or without bladders. Gizzard strongly developed (cf. *Microscolex*) in 5-7 (or 8 in *monticolus*?), extramural calciferous glands absent. Last hearts in 12 or 13. Spermathecae diverticulate.

Distribution: Endemic to New Zealand with about 30 species, especially on the North Island, also found on neighboring islands. Two species are known from Australia: *Rhododrilus queenslandicus* Michaelsen, 1916 is reported from Cape York Peninsula, north Qld., *R. kermadecensis* Benham, 1905, originally described from Kermadec Islands is found around Tasmania especially in tidal mudflats, and on Kangaroo Island, SA. Such species are probably not native to Australian and may have been introduced and become naturalised and speciated following introduction (in recent times?), or possibly they are relict fauna of ancestral stock shared with other regions and now isolated (Blakemore, 1994a:297).

In New Zealand, at least eight kinds of earthworms, including *Rhododrilus edulis* Benham, 1904, were a prized dish formerly used in Maori feasts (Stephenson, 1930: 657). Prevailing currents are in the opposite direction, although it is remotely possible that those of relatively small size, such as *R. kermadecensis* described below, were carried by boat from New Zealand along with the root-stock of plants or perhaps larger specimens were taken as part of a food resource in themselves, although neither case is proven and there is no current evidence for ancestral Maori in Australia.

Note: The above diagnosis is emended to exclude meroic forms, e.g. *Rhododrilus disparatus* Lee, 1952 which was transferred to *Leucodrilus* Lee, 1952 by Blakemore (1999, in Lee *et al.*, 2000; Blakemore, 2004f – see also Blakemore, 2010). *Microscolex monticola* Beddard, 1895 (= *Rhododrilus monticolus*) from Mt Pirongia, Auckland was listed as *incertae sedis* by Lee (1959: 255).

Rhododrilus kermadecensis Benham, 1905

Fig. 1.14 *Rhododrilus kermadecensis* from Swan Bay, Tasmania (collected by author).

Rhododrilus kermadecensis Benham, 1905: 298, Pl. XIII, Pl. XIV, figs. 1, 4-5.). [Type-Locality, Coral Bay, Raoul, Kermadec Islands. Types not located]; Benham,

1915: 147; Lee, 1959: 161, figs. 133, 134; Blakemore, 1999; 2000: 557 (syn. *littoralis*); 2002; 2007; 2012; 2016.

Rhododrilus littoralis Jamieson, 1975: 213, figs 4, 26c, 32e.

[NOTE1: "***kermadecensis**, Rhizodrilus* Benham, 1915; Trans. N.Z. Inst. 47: 180; typus amissus. [N.O., p. 122]" is a Tubificid.

NOTE2: "***kernadecensis**, Rhododrilus* Benham, 1905; Trans. N.Z. Inst. 37: 298; typus amissus. [N.O., p. 122]" is a *lapsus* mispelling as "kerNadecensis"].

Distribution: Coral Bay, Raoul, Kermadec Islands; Tasmania (Swan Bay, Eagle Hawk Neck, Hobart and possibly Strahan); Kangaroo Island, SA (J. Buckerfield, pers. com.).

Locality: Swan Bay, Tamar River, N. Tasmania, collected 31.v.1996, by R.J.B (when my VW Kombi bogged).

Habitats: Swan Bay specimens from mud flat beneath sedges and under driftwood, in high numbers; other Tasmanian material coastal, from kelp on rocks, etc.

Registration No.: QVM: 14:3473-3474, several specimens collected by the author. Other specimens of this species are lodged in QVM collection and at the Tasmanian Museum (TM: K396-400 inspected, K397 is a previously undissected immature that is possibly a different species).

Behaviour: Euryhaline?

Length: 52-70 mm (cf. Benham, 65mm).

Width: 1.5-2 mm.

Segments: Ca. 90 (cf. Benham, 108).

Colour: In life, pinkish (Benham) or with anterior brown, clitellum brown-buff, rest of body unpigmented except for yellow tail tip.

Prostomium: Open epilobous.

First dorsal pore: None found but Benham notes them "posteriorly".

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment from 2; ab closely paired, cd widely paired; setae ab on 17 modified as large penial setae.

Nephropores: Not clearly seen, possibly in b setal lines at intersegments 4/5/6, (cf. Benham, in c lines).

Clitellum: Saddle-shaped, ½13-17 (or 13-18 inclusive, Benham).

Male pores: On 17, in raised circular porophores each wider than ab, with enlarged penial setae protruding (on preservation).

Female pores: Pair anterior to setae ab in 14.

Spermathecal pores: 6/7/8/9 in setal b lines.

Genital markings: Elongate tumid pad in 19/20 ventrally.

Septa: None especially thick.

Dorsal blood vessel: Single to 13 or 14 from whence it is doubled but fuses at successive septa (seen in all specimens); supra-oesophageal vessels present (seen in 9-14 or 13-16).

Hearts: 10-13 from dorsal vessel.

Gizzard: Small, muscular in 5.

Calciferous glands: None but oesophagus dilated in 13-14 (Benham) and vascularized in 13-15,16.

Intestine origin (caeca, typhlosole): 18, (no typhlosole).

Nephridia: Avesiculate holoic, as thickened tubules approximately in line with b setae that send ducts to body wall at in mid-bc lines.

Male organs: Testes/funnels free in 10 and 11; seminal vesicles in 9, 11 and 12.

Ovaries: Large in 13; ovisacs absent.

Prostates: Tubular extending to 23 or 24, on short flaccid duct; long penial setae present extending back from the 17th to the 21st segment (each sac contains three setae, Benham).

Spermathecae: In 7, 8 and 9; ampula saccular with single, often bent or constricted diverticula (not iridescent).

Gut contents: Mud.

Notes: Setal ratios were found to vary depending on preservation methods used. Lack of spermathecal iridescence suggests this species is parthenogenetic.

Remarks: Benham's original description is augmented to note the hearts in 11-13 (rather than 10-13), and the dorsal blood vessel divided after segment 13, otherwise agreement is good and in particular his figure of a spermatheca agrees with those found here. This species is very similar to *Rhododrilus cockayni* Benham, 1905 but Benham separates it on its colour, dimensions, arrangement of GM in 19/20 and the penial setae form. Lee (1959: 131) further separates *R. cockaynei** on its last hearts in 12 and single pair of oesophageal glands in 13; it is also widespread (possibly also due to drifting) on a number of subantarctic islands and South Island, NZ (e.g., see Michaelsen, 1924).

*NOTE: Originally spelt *cockayni* by Benham (1905) in honor of his colleague Dr L. Cockayne, Lee (1959: 153) subsequently changed it to *cockaynei* on the grounds that the Doctor's name ended in an e. However, under ICZN (1999: Art. 31.1.2, Example) this is an invalid emendation and the correct name must be retuned as *cockayni*.

Genus ***Yagansia*** Michaelsen, 1899

Yanagisa Michaelsen, 1889: 237; 1900: 156.

Type-species: *Cryptodrilus*? *spatulifer* Michaelsen, 1889 (syn. *Yagansia chilensis* Cognetti, 1906) from Chile.

Diagnosis: Setae lumbricine. Microscolecine, male pores paired on 17 or 18 with pores of tubular prostates paired nearby in 17. and spermathecal pores a single pair in 8/9 (or 7/8?). Gizzard single in (5 or) 6. Calciferous glands absent. Nephridia holoic.

Distribution: Central and South America, and originally from South Africa too for *Y. kinbergi* Michaelsen, 1899 that was later made type of *Udeina* Michaelsen 1910 and subsequently put in synonymy in *Parachilota* Pickford, 1937 but restored by Plisko (2004). There are approximately 12 species and subspecies in *Yagansia* and one species, *Y. longiseta*, is possibly peregrine.

Remarks: Michaelsen (1900: 122) separated *Yagansia* from *Chilota* by its one pair of prostates (and one pair of spermathecae), rather than two pairs typical of this other genus; its gizzard is in 5 or 6. This genus was recently reviwed by Zicsi (1989, 2003).

Yagansia longiseta (Beddard, 1895)

Microscolex longiseta Beddard, 1895b: 229. [Uschuia, Puerto Pantalon, Navarin, etc. Types missing]; Beddard, 1895a: 466 [redescribed as "NEW SPECIES"].

?*Microscolex papillosus* Beddard, 1895b: 230. [Uschuia. Types BMNH 1904:10:5:497]; Beddard, 1895a: 465 [redescribed as "NEW SPECIES"]

Yagansia longiseta : Michaelsen, 1900: 160 (separate from *Y. papillosa* p. 159); Csuzdi, 2003 website (syn. *papillosus* - from Zicsi, 1989?); Zicsi, 2004: 122 (syn. *papillosus*) [although there are considerable differences in original descriptions and as given in Michaelsen (1900: 159-160)?].

Distribution: Chile (Tierra del Fuego; Puerto Pantalon; Uschuia; Navarin island; Klap San Pio; Hoste; Puerto Toro; Puerto Edén; Monington and Grant islands; Smyth channel; Punta Arenas; Gordon and Steward islands (Beddard 1895a: 210); Argentina, Paraguay. Possibly introduced into "*North America, Madeira island, and Africa*" with a source claimed as "*Ude (1896: 36)*" as reported by Martin L. Christoffersen (pers. comm. April, 2008) although this is unverified and Ude's paper was unavailable.

The South African record is probably of *Yagansia kinbergi* Michaelsen, 1899, as noted by Michaelsen (1903: 74), that was subsequently reallocated to *Udeina*.

Diagnosis: Puce. Length 40 mm [87 mm for *Y. papillosa*] by 3 mm. Segments 95. Incomplete (= epilobic?). Dorsal pores present. Clitellum 13-16,17. [GM unpaired papillae in 7-17 in *Y. papillosa*]. Gizzard in 6 [in 5 in *Y. papillosa*]. Last hearts in 12. Seminal vesicles in 11 [or 9 and 11 in *Y. papillosa*]. Penial setae 6 mm [10 mm in *Y. papillosa*] long corresponding with a spiraling diverticulum of spermathecae in 9.

Remarks: The synonymy (and priority!) of *Microscolex papillosus* Beddard, 1895 is perhaps questionable as there are considerable differences in original descriptions and as given in Michaelsen (1900: 159-160), as noted in the synonymy above. Confirmation of the description and full distribution range is thus pending.

Family **Octochaetidae** Michaelsen, 1900

Typhaeidae (part.) Benham, 1890: 221.

Benhamiacea (part? priority?) Michaelsen, 1895: 23.

Benhamiinae (part? priority?) Michaelsen, 1895; 1897; 1899: 243.

Octochaetinae Michaelsen, 1900: 121, 31; 1909: 199.

Octochaetidae Gates, 1959, Blakemore (2000, 2013) – definitions differ substantially.

Type-species: *Octochaetus multiporus* (Beddard, 1885) from New Zealand.

Diagnosis: Male pores acanthodriline, i.e., paired usually on 18 separate from pores of tubular prostates paired on adjacent segments, or paired on 17, 18 or 19 separate from a single pair of prostatic pores on the same segment (i.e., not united on 18 as in the Megascolecidae); sometimes male and prostatic pores doubled on both 17 and 19 (or in 17/18 and 18/19) e.g. in *Hoplochaetella* Michaelsen, 1900: 321. Usually lumbricine, or rarely anisochaetine (e.g. *Wahoscolex* Julka, 1988: 342) to perichaetine (especially some New Zealand genera and in *Hoplochaetella*). Meroic (i.e., non-holoic). Oesophageal gizzard(s) present, or rudimentary, or absent; calciferous glands commonly present, but not arranged as in the Ocnerodrilidae, or absent; intestinal gizzards absent. Spermathecae with or without external diverticula. Last hearts >11.

Type genus: *Octochaetus* Beddard, 1893: 668. Type-species: *Acanthodrilus multiporus* Beddard, 1885: 813; Types BMNH 1904:10.5:877 (corr. to 1904:10.20.47-55,58-60) from Canterbury Plains, N.Z. – see Lee,1959: 115; Blakemore, 2004f, 2012; [?syn. subsequent *O. thomasi* Beddard, 1893: 671, fig. 2; type BMHN 1904.10.5.1136 (corr. to 1904:10.5.241) from Canterbury Plains. Treated separately (and both figured) in Beddard (1895), considered synonymous by Michaelsen (1900: 319); but restored by Lee (1959: 115, 121) and Blakemore (2004f). Note, however, that Springett et al.'s (1998) specimens from their extensive ecological studies were sent to British Museum and Ed Easton, the then curator, identfied them as *O. thomasi* rather than *O. multiporus*. Moreover, it is slightly possible that much smaller (35 mm) *Acantothodrilus levis* Hutton, 1877 has overall priority for both. This issue has yet to be satisfactorily resolved (pers, obs. RJB, Jan., 2017)].

Distribution and diversity: Australia (recent determinations by current author), New Zealand, India into Myanmar, Indian Ocean, Madagascar, tropical Africa, tropical America, with *Dichogaster* spp. especially introduced into other regions. Endemic distribution maps for the genera of the proposed sub-family Benhamiinae in Africa and Southern/Central America are shown in Csuzdi (1996). In determining true

endemicity it is important to look at the frequency and reliability of reports of particular taxa from the various regions. Around 585 species are known (see above – with 200 or so dichogastrids – Ref.), and 43 genera are listed [Ref. Feb. 2006] but several of these are now transferred either to Acanthodrilidae or to subfamily Benhamiinae of Octochaetidae (see Csuzdi, 1996; Blakemore, 2007); thus true totals are obscured by past revisions that have variously merged the family boundaries.

Remarks: Michaelsen (1909: 199) presented a strong argument and explanation for the validity of what was then a sub-family of MEGASCOLECIDAE. It was further recognized by Blakemore (2000b: 37; 2004d: 124) that some latter authors considered this 'Classical family' a derived grade, meriting only sub-family rank in the Acanthodrilidae Claus, 1880, or as being polyphyletic. However, if we accept the Linnean/Darwinian taxonomic concepts of "*Similarity and common descent*", then it is obvious that Octochaetids are derived from and descendents of Acanthodrilids – whenever and where-ever this occured. Moreover, as already noted, Monophyly in Linnean taxonomy is a logical impossibility because of this. Thus the origin of Octochaetidae is from Acanthodrilidae, yet its restriction to the New Zealand type-genus *Octochaetus* Beddard, 1893 (see Blakemore, 2004f) and other allied Australo-Indian genera is possible; moreover, Csuzdi (2000) places *Dichogaster* subgenera in his redefinition of ACANTHODRILIDAE subfamily BENHAMIINAE Michaelsen, 1895 that possibly merits elevation to family level status or transfer to Octochaetidae as a subfamily (Blakemore, 2013). In his revisions of the Octochaetidae, Csuzdi (1995, 1996, 1997, 2000) established three subfamilies of Acanthodrilidae: an holoic Acanthodrilinae, meroic Octochatinae plus meroic Benhamiinae Michaelsen, 1897 with the 2-3 pairs of ***extramural*** calciferous glands of the latter sub-family beginning in or near segment 14 (cf. oesophageal glands in some of 14-17, or absent, in *Octocheatus* type-genus). Csuzdi's sub-families are not wholly accepted herein. Note that a 2014 paper from proceedings IOTM VI on Mexican worms by several authors seems to accept my version but misspelt "*OCTOCHETIDAE*"!

The genera *Megascolides* McCoy, 1878; *Scolioscolides* Gates, 1937; *Barogaster* Gates, 1939; monotypic meroic *Priodochaeta* Gates, 1940: 116 (transferred from holoic *Diporochaeta*) and its probable junior synonym, monotypic *Priodoscolex* Gates, 1940: 122; lumbricine, meroic *Travoscolides* Gates, 1940: 137 (?= *Megascolides*); and perichaetine, meroic *Celeriella* Gates, 1958 are now transferred to the Megascolecidae from Octochaetidae *s*. Gates, as their male and

prostatic pores are combined on 18 rather than being acanthodriline; cf. Gates (1972: 313; 1982: 14 with "*Megascolidea*" misspelling) and Julka (1988) who maintain these genera in Octochaetidae.

Recently Julka *et al.* (2004) described octochaetid taxa in earthworm material collected during ecological studies from the Western Ghats, a biodiversity hot spot in South India. There were three new genera: *Senapatiella* with three new species (*S. alfredi, S. ghatensis, S. herbettuensis*); *Shimodrilus* with two new species (*S. bhatkalensis, S. karniensis*) and *Herbettodrilus* containing one new species (*H. bahli*). Other new species were *Konkadrilus shimogensis, K. gatesi, Hoplochaetella lavellei, Karmiella sulvalliensis* and *Wahoscolex michaelseni*.

The holoic taxa included by Csuzdi & Zicsi (1994: 230) in their Octochaetidae : Benhamiinae and by Csuzdi (1995; 1996; 1997; 2000) in his "Acanthodrilidae: Benhamiinae" – viz. *Pickfordia* (*Pickfordia*) Omodeo, 1958, *Pickfordia* (*Omodeoscolex*) Csuzdi, 1993, *Wegeneriella* Michaelsen, 1933 (non *Wegeneriona* Cernosvitov, 1939 that is in Octochaetidae) and "*Eodrilus*" Michaelsen, 1907 synonym of *Diplotrema* – actually belong in Acanthodrilidae as redefined herein. Meroic *Ramiellona* Michaelsen, 1935 (type *R. stadelmanni*), as diagnosed by Csuzdi (1997: 46) including Guatemalan *R. strigosa strigosa* Gates, 1962 [or "*Ramionella strigosa*" (lapsus) by Csuzdi (1997: 46)] that has recently been found in Mexico too, and the Mexican *R. wilsoni* Righi, 1972, is returned to meroic Octochaetidae rather than holoic Acanthodrilidae. Other meroic genera treated by Csuzdi (1996; 1997), including *Wegeneriona* Cernosvitov, 1939 (non *Wegeneriella* Michaelsen, 1933) and *Omodeona* Sims, 1968, are similarly returned to the Octochaetidae as redefined herein.

Remaining in Octochaetidae and/or Benhamiinae/idea are Neotropical genera such as *Cubadrilus* Rodrigues & Fragoso, 2002 that was stated to be very close to the (polyphyletic) meroic Mexican *Zapatadrilus* James, 1991, indeed several species of both genera, not types, are actually placeable in *Exxidus* (family Exxidae) – pers. obs..

As noted by Stephenson (1923: 402), Indian species [viz. *indica*, *poonensis* Fedarb (non *pooensis* Cognetti, 1910), and *parva*] previously included in the Caribbean genus *Trigaster* Benham, 1886 (type *T. lankesteri* Benham, 1886 from the Antilles) were transferred to the genus *Eudichogaster* Michaelsen, 1903 (type *Benhamia indica* Beddard, 1896). *Trigaster* species lacking extramural calciferous glands, as for the type, remain in Octochaetidae *s. stricto*, several new taxa were described by Boges & Moreno (1991). Perhaps because its calciferous glands are

uniquely in the region of 10-13 (Stephenson, 1923: 402), James (1991), Csuzdi & Zicsi (1994), and Csuzdi (1994) omit consideration of the genus *Eudichogaster* in their redefinitions of *Trigaster*, *Benhamia*, and *Eutrigaster*, respectively.

The Indian *Octochaetoides* Michaelsen, 1922 and *Octochaetona* Gates,1962 are similar to the New Zealand *Octochaetus* Beddard, 1893 – the type-genus of the (sub-)family, whereas the monotypic West African genus *Monogaster* Michaelsen, 1915 (type-species *M. bidjumensis* Michaelsen, 1915 from Cameroon) now belongs in (Octochaetidae) Benhamiinae according to Csuzdi (1996: 358). This latter genus has a combined gizzard in 5-6, extramural calciferous glands in 15-17 and saccular meroic nephridia. Julka (1988: 298) transferred *Octochaetus roseus* Gates, 1926: 259 (syn. *Octochaetoides sudarshensis* Sharma & Chako, 1970; sometimes quoted as "*O. rosea* Stephenson, 1926") into his new genus as *Octonochaeta rosea* (Gates, 1926)

It has for some time been anticipated that Australia, intermediate between N.Z. and India distributional range, would also have endemic representatives e.g. Michaelsen (1909) as quoted by Lee (1959: 26). The long anticipated 'missing link' of endemic octochaetids in Australia, under the current system of classification, appears in the form of *Octochaetus ambrosensis* (Blakemore, 1997) – types of this species in ANIC collection but under provisional name of *"Diplotrema ambrosea*" – see Blakemore (2008). This and several related Australia spp. actually having meroic nephridia were previously misplaced in holoic *Diplotrema* (see Blakemore, 2000: 34; 2004f).

Seven exotic octochaetids were reported for Australia by Blakemore (1994a; 1999), including *Octochaetona beatrix* (Beddard, 1902) recorded for the first time at two widely separate Qld locations, both sites agricultural. Despite the current revision of Octochaetidae, no argument is put forward for considering the peregrine *O. beatrix* and its sibling species *O. surensis* Michaelsen, 1910 as Australian endemics.

It is probable that Hoplochaetelline genera (e.g. Indian *Hoplochaetella* with duplicated male and prostatic pores should be separated to a new family (see Blakemore, 2013).

There now appears some argument for separating Octochaetidae into two or more sub-families (Csuzdi, 1995, 1996, 2000; Blakemore, 2013), or even the elevation of Benhamiinae(or Trigastrinae) to full family status for those meroic genera from Africa/America as discussed by Csuzdi (1996). Octochaetinae/-dae would then

be restricted to *Octochaetus* and related Indo-Australasian genera. As noted above, I do not agree with Csuzdi's placement of holoic genera into Octochaetinae/-idae, rather they should remain in the Acanthodrilidae as defined by Blakemore (2000) and herein.

Generic foundation for division discussed above is from Beddard (1893: 668): "***Octochaetus*** nov. gen. *Prostomium not continued by grooves on to buccal segment; clitellum xiii-xix.(xx.); male pores on prominent papillae; setae distant; ventral setae present on segment xviii; a single gizzard in vi., or v. and vi., or v.; calciferous glands one or two pairs, in xvii., xviii., or xv. and xvi.; typhlosole well developed; nephridia diffuse; a mucous gland present; dorsal vessel double from seventh segment onwards; diverticula of spermatothecae very minute. - Distribution: New Zealand.*"

Current *Octochaetus* distribution is NZ and Australia with Indian spp removed.

Beddard tentatively separated his genus from species of the prior *Benhamia* Michaelsen, 1889 by their gizzards being a segment or two further backwards; by their (always?) having penial setae, whereas the setae on 18 in *Octochaetus* are unmodified; and by their calciferous glands being reniform and extramural usually in 15-17, rather than as lateral pouches in *Octochaetus*.

For *Benhamia* Michaelsen, Beddard (1893: 670) proferred this definition: "***Benhamia*** Michaelsen....*clitellum xiii.(xiv.)-xix.(xx.); setae strictly paired; two gizzards in vi.,vii., or vii.,viii.; calciferous glands three pairs, in xiv.-xvi. or xv.-xvii.; nephridia diffuse; dorsal vessel single; penial setae nearly always present; no ventral setae upon xviii. - Distribution: Tropical Africa, Tropical America, and India.*" India is now excluded, cf. *Eudichogaster*.

Key to genera of Octochaetidae/Benhamiinae with peregrine members

1. Oesophageal gizzard single or absent, calciferous glands present or absent 7

Oesophageal gizzards double or multiple (in some of 5-7 or 7-9) 2

2. Calciferous glands three pairs in 10-12 (gizzards in 5-6) ..... *Lennogaster* Gates, 1939 from north-east India/Myanmar/Bangladesh[1].

Calciferous glands three pairs in 15-17 3

Calciferous glands two or more pairs in 10-13 (gizzards in region of 5-6) ..... *Eudichogaster* - from (West and Central) India (cf. *Ramiella* and *Lennogaster*).

Calciferous glands absent (gizzards in 5-7 or 7-9) ..... *Trigaster* Benham, 1886 from Virgin Islands/Puerto Rico [cf. related Caribbean genera lacking calciferous glands: *Borgesia*, *Neotrigaster*, *Zapatadrilus* all by James, 1991 and *Cubadrilus* by Rodriguez & Fragoso (2002); also members of these genera that belong to family Exxidae with non-tubular prostates] [2].

3. Gizzards in (5)6-7 .... *Eutrigaster* Cognetti, 1904, with subgenus *Graffia* Csuzdi & Zicsi, 1991 (now *Graffiona* Csuzdi, 2014) having penial setae; from Central America and Caribbean Islands. [3]

Gizzards in 5-6 4

4. Nephridia with numerous interconnected tubules ... *Benhamia* Michaelsen, 1889 [type *B. rosea* Michaelsen, 1889: 6 from "Ober Guinea (Gabun und Leibange)" (?= Sierra Leone); [Non *Dichogaster rosea* Michaelsen, 1935 (= *Dichogaster hamburgensis* Omodeo, 1958)], widepread across much of tropical Africa.

Nepridia saccular (usually in 4 or more rows) 5

5. Intestinal caeca absent 6

Intestinal caseca present ..... *Millsonia* (type *M. nigra* Beddard, 1894) and its sibling taxa: *Reginaldia* (*Reginaldia*) (type *R. ghanensis*) and *Reginaldia* (*Peritogaster*) [type *R.* (*P.*) *anomala* (Omodeo, 1955)], widespread in tropical West Africa and possibly sometimes transported [but see Sims (1986)].

6. Dorsal pores begin behind 9/10; (?spermathecal ampulla simple) ..... *Dichogaster* (*Dichogaster*) Beddard, 1888 - mainly West Africa, some species (including type, *D. damonis*) from Pacific Islands.

Dorsal pores from region of 5/6; (?spermathecal ampulla 'waisted') ..... *Dichogaster* (*Diplothecodrilus*) Csuzdi, 1996 - endemic to tropical Africa and Central/South America, many common peregrine species. [Note: this couplet, erronrously inverted in Csuzdi (1996: 365) key, is corrected here].

7 (1). Discrete extramural, calciferous glands present 8

Discrete calciferous glands absent (embedded in oesophageal wall in 12) ... 10

Discrete calciferous glands absent (swelling on oesophageal wall in 16) ... *Howascolex madagascariensis* Michaelsen, 1901 [other species from India separated off to lumbricine subgenus *Graceevelynia* Graff 1957 (now = *Ramiellona*) or to *Konkadrilus* and either lumbricine or perichaetine *Wahoscolex* by Julka, 1988].

8. Calciferous glands three pairs in 15-17 (caeca/gizzard present or absent) 9

Calciferous glands two pairs in 14 & 15 (spermathecal pores midventral) .....*Wegeneriona* - from South America.[4]

Calciferous glands one pair near 15/16..... *Octochaetona*, endemic to peninsular India, two species peregrine.

9. Intestinal caeca absent; gizzard single in 5-6 ..... *Monogaster* - type *M. bidjumensis* (sometimes misspelt "bidjumensi") from Cameroon, West Africa

Intestinal caeca present, gizzards reduced ..... *Agastrodrilus* - carnivorous earthworms from West Africa (cf. *Millsonia*)

10 (7). Gizzard single but occupying several segments; a pair of calciferous glands imbedded in oesophageal wall in 12; male pores on 17 just behind openings of prostatic pores ..... *Eutyphoeus*, Myanmar/Nepal/Pakistan/India with some recent limited extensions due to human transportation.[5]

Gizzard single in 5 or 6; calciferous glands absent; male pores on 18 separate from prostatic pores on 17 and 19 .... *Ramiella*, from India, the type-species more widely transported. [Note: this genus said to be holoic by Stephenson (1923) but revealed as meroic by Gates (1972)].

Notes: Gates (1972) speculated that *Octochaetona* and *Ramiella* representatives in Burma were peregrine species taken there before the arrival of the Portuguese. Most common small cosmopolitan *Dichogaster* are in (sub)genus (*Diplothecodrilus*) Csuzdi, 1996 but, as sub-genera are mostly unnecessary, it is omitted below. *Omodeona* Sims, 1967: 32 (type: *Omodeona proboscoides* Sims, 1967: 33 BMNH 1966:30:483-512 (= *Dichogaster fallax* Cognetti, 1910: 88 MZUT: 64 according to Csuzdi & Zicsi (1994).

[1] *Lennogaster* has two species that have possibly been transported. The litter dwelling/composting *Eudichogaster barkudensis* Stephenson, 1921, now a junior synonym of *Le. pusillus* (Stephenson, 1920) common in South India, was reported

from Sumba Island south of Flores, Indonesia by Gates (1972: 306) although this locality was overlooked by Julka (1988: 252). This species is said to cast at the surface in the form of small towers with central openings. And *Le. chittagongensis* (Stephenson, 1917) [non *Eutyphoeus chittagongianas* Michaelsen, 1907 (= *E. gammiei*)] from Northern India and Bangla Desh was recorded as possibly introduced to the Shan plateau, Myanmar by Gates (1972: 307).

[2] *Trigaster minima* Friend, 1911: 274 described on specimen(s?) in soil imported to Kew (from the Caribbean?), type missing; overlooked in revisions by subsequent authors thus of uncertain status. As noted above, Michaelsen had placed the prior Benhamiinae Michaelsen, 1895/7 in his Trigastrinae Michaelsen, 1900 but perhaps they should both be combined under the earlier name [cf. Csuzdi (1996: 351) who excluded genera such as *Trigaster* that lacked extramural calciferous glands from Benhamiinae, retaining them instead in Octochaetidae]. Trigastrinae type-genus *Trigaster* (type: *Trigaster lankesteri* Benham, 1886) is defined thus (after Michaelsen, 1900): Acanthodriline with male pores on 18 and tubular prostates in 17 &19; (metandric with seminal vesicles in 12); spermathecae paired in 8 and 9, three gizzards in 5-7 or 7-9; calciferous glands absent; nephridia meroic; hearts in 10-13; ventral vessel absorbed in some of 5-9 corresponding to the presence of gizzards. Distribution: Virgin Islands, Puerto Rico, (Kew).

[3] *Eutrigaster* (*Graffiona*) *godeffroyi* (Michaelsen, 1890) from Haiti (Puerto Plata) was reported from New Zealand as *Dichogaster godeffroyi*, but this was considered undoubtedly incorrect by Michaelsen (1900: 355). *Eu.* (*Gr.*) *sporadonephra* (Cognetti, 1905) is from Ecuador, El Salvador, Costa Rica, Panama and Mexico.

[4] *Wegeneriona cernosvitovi* Righi & Caballero, 1970 from Brazil and possibly transported to Equador (Csuzdi, 1993: 68).

[5] *Eutyphoeus foveatus* (Rosa, 1890) was presumed to be transported to Mandalay and from Prome to Naba; and *E. peguanus* (Gates, 1925) sub-species have possibly been transported by humans; whereras *Eutyphoeus gammiei* (Beddard, 1888) (syns. *chittagongianus, koboensis, magnus*) and *Eutyphoeus waltoni* Michaelsen, 1907 (syns. *bengalensis, ibrahimi* and sometimes misspelt "valtoni" or "waltonii") apparently have natural wide distributions. Soil imported to Kew Gardens held *Eutyphoeus nicholsoni* (Beddard, 1901: 195) (originally *Typhoeus nicholsoni*; syn *Eutyphoeus khani* Michaelsen, 1907: 233 from India). See genus *Eutyphoeus* description below for further details.

Genus ***Dichogaster*** Beddard, 1888

Dichogaster Beddard, 1888: 251; Michaelsen, 1900; Stephenson, 1930.

[Syns: *Microdrilus* Beddard, 1893 (type *Microdrilus saliens*), and *Balanta* Michaelsen, 1898 (type *Balanta ehrhardti*) are in synonymy of *Dichogaster* following Michaelsen (1900: 334), but *Millsonia* Beddard, 1894 (type *M. nigra*) that was included by Michaelsen (1900: 367) is now removed (see Sims 1986; Csuzdi, 1996: 360; 2006)].

Sub-genera, mostly unnecessary, are *Dichogaster* (*Diplothecodrilus*) Csuzdi, 1996 and *Dichogaster* (*Malawia*) Csuzdi, 2010 that was preoccupied and is now replaced with *Dichogaster* (*Andrassyona*) Csuzdi, 2014.

Type-species: *Dichogaster damonis* Beddard, 1888: 251 - an enigmatic species from Fiji characterized by three pairs of prostates in 17-19 (as in *D. townsendi* Eisen, 1900) , that has yet to be rediscovered. However, my reintepretation on re-reading Beddard (1888) is that only the first pair that opens on 17 combined with the vasa deferentia are true prostates, the other two pairs of glands may have copulatory function associated with the genital markings on 18 and 19. Csuzdi & Zicsi (1994: 215) claim to redescribe the type-species of *Dichogaster* but this must be an error as I read through their paper three times and can find no mention of *Dichogaster damonis*.

Diagnosis: Lumbricine. Male pores acanthodriline but sometimes with microscolecine or balantine (e.g. *D. ehrhardti*) reduction. Excretory system, meroic, nephridia exoic (except 2-4?), astomate and tubular/discoid ("*saccular*" by Pickford, 1938). Digestive system with two gizzards in front of 8/9 (usually in 5 and 6), an intestinal origin in 15 [according to Csuzdi (1996: 350) cf. cited as in "xix" = 19 by Gates (1972: 177)], a lamelliform typhlosole beginning in the region of 22-23 and lateral typhlosoles through some or all of 22-29, but without caeca and supra-intestinal glands. Calciferous glands, trilobed, a vertically reniform lobe in each of 15-17, the common duct opening dorsolaterally in 16. Last hearts in 13. Prostates tubular, with long penial setae. Dorsal pores present. Intersegmental furrow 1/2 often faint or indistinct.

Distribution: What Gates (1982: 16) calls "*An Afro-American, clasical congeries of about 200 species*". Current lists of *Dichogaster* still number nearly 200 spp. (Ref.), several of these have circumtropical distributions by introduction and no endemics are recorded from South-east Asia nor Australia, but the small size of the species means that

they are easily overlooked by cursory survey. Especially common on some, but not all, Pacific Isles. Whether the original home is in tropical Africa or America, or both, is largely undetermined but the large number of *Dichogaster* species from Central and West Africa (e.g. Csuzdi & Zicsi, 1989) and from species and related genera, such as *Eutrigaster* Cognetti, 1904, from the Caribbean and Central and South America (Csuzdi & Zicsi, 1991), attest to a wide endemicity. Stephenson (1931b: 35) thought the genus endemic to America and tropical Africa, but neither he nor Gates (1972: 278) were sure if the original home of the exotics was in Africa or America. Csuzdi (1996: 354) similarly regards the generic homeland in both tropical Africa and Mid- and South America. The relatively few peregrine species are characterized in the generic diagnosis above and keyed below (after Sims, 1967; Gates, 1972 and Csuzdi, 1996).

Csuzdi (1995; 1996) reviewed the species and used theories of plate tectonics to explain endemic distributions while creating a new subgenus *Diplothecodrilus* Csuzdi, 1996: 355 with type *Dichogaster (Diplothecodrilus) annae* (Horst, 1893), however this is not implemented in the taxonomic headings of the following accounts.

Key to Common Peregrine *Dichogaster* species (especially in Australasian/Oriental region - other species possibly widepread endemics in Africa and/or the Americas)

1. Quadriprostatic, i.e., two pairs of prostates..... 3
   Biprostatic, one pair of prostates..... 2
2. Spermathecae in a in 7/8/9; genital markings usually in 15/16 ….. *D. saliens*
   Spermathecae in ab in 8/9; genital markings present or absent ……. 6
3. Female pore single/central..... *D. bolaui*
   Female pores paired..... 4
4. Median genital markings usually present..... *D. affinis*
   Genital markings lacking..... 5
5. Gizzards in 6 and 7; spermathecal duct narrow and ampulla narrow (ental diverticulum with seminal chambers that are often multilocular) ……..... *D. annae*
   Clitellum annular only in 13; gizzards 7 and 8; spermathecal duct bulbous (small diverticulum on short stalk mid-length on duct) …..... *D. modiglianii*
6. Genital markings (?) paired in line with male pores in 18 and 19 associated with glands internally that somewhat resemble the prostate glands in 17……..... *D. damonis*
   Genital markings absent ……. *Dichogaster sp. nov*?*

[Cf. Key in Eisen, 1900: 226].

* A "*Dichogaster sp*." was identified by RJB in a sample (ANIC RB.95.27.2) provided in January, 1994 by Randal Hinz from a 20-year-old rehabilitated mined area in lateritic soils at Gove Peninsula, Northern Territory, Australia characterized thus:

> One pair of spermathecal pores in ab lines in 8/9. Two oesophageal gizzards in 7 & 8, three pairs of calciferous gland in 15-17, prostates paired in 17 only with long penial setae. Spermathecal duct tapering from spheroid ampulla with small diverticulum mid-length, nephridia in appoximately 10 rows per side.

Searches of the literature have failed yet to find an exctly corresponding description and I refrain from describing the single available specimen which is clearly a non-native. Perhaps the most similar species are *Omodeona braunsi* (Michaelsen, 1895) or *Monothecodrilus scherbroensis* (Michaelsen, 1910) from Sierra Leone that have, respectively, either paired, or unpaired and bidiverticulate, spermathecae in 8/9. Other specimens from this site were *Dichogaster saliens* and a new native *Diplotrema sp*. (which I shall shortly publish). Care was taken not to intermix the NT material identified with *Dichogaste*r *bolaui* and *D. saliens* in samples sent at the same time from a 4-year-old reclaimed project site in Sierra Leone, West Africa (collected by R. Hinz in 1993).

Apart from the common species keyed above, the following erstwhile peregrine *Dichogaster* species are also reported:

Dichogaster (*Dichogaster*) *corticis* (Michaelsen, 1899: 80) (originally *Benhamia corticis*), (syn. *Dichogaster tamiana* Cognetti, 1911: 6 from Humboldt Bay, north coast West Papua). Types from Masarang-Gebirge (cited as Masarang-Kette in nmb.bs.ch/NaturmuseumBasel/LinksNMB/Sammlung/Kataloge/Guertelwuermer.xls), North Celebes. Csuzdi (1996: 355) retains this species in his subgenus *Dichogaster* as Michaelsen (1900: 355) describes first dorsal pore in 10/11 and Cognetti (1911: 6) has it in 11/12.

Eudichogaster parva (Fedarb, 1898: 449) (originally *Dichogaster parvus*) from Uttar Pradesh, India was poorly described and has possibly been confused with *Benhamia parva* Michaelsen, 1896 (now = *Dichogaster annae*) by subsequent authors after its combination as *Trigaster parva* by Michaelsen (1900: 334).

Eudichogaster poonensis (Fedarb, 1898: 434) [originally *Benhamia poonensis* non *Dichogaster pooensis* Cognetti, 1910] from Poona east India, was previously placed in *Trigaster* by Michaelsen (1900: 333).

Dichogaster (*Dichogaster*) *reinckei* (Michaelsen, 1898) which was possibly introduced to Samoa. [Michaelsen (1914) described a variety from tropical Africa he called *D. reinckei endemica* that Csuzdi recently elevated to specific status as *Dichogaster (Dichogaster) endemica* Michaelsen, 1914: 89].

Dichogaster (*Diplothecodrilus*) *gatesi* Csuzdi, 1997: 42, figs. 13-15 (syn. *Dichogaster* sp. Gates, 1977: 486) was collected 16.vii.1959 by A. Loveridge from St Helena, a British protecorate island in the South Atlantic, inspected by Gates (1977) and described by Csuzdi (1997: 43) who also lists a specimen from "*Insel St. Helena, Scotland, 17.07.1965 leg. A. LOVERIDGE, Inv. Nr. BM (NH) 1995.05.12.545-558*". This Scottish report is possibly a mistake of labeling or, more likely is the name of the property on St Helena.

Dichogaster (*Diplothecodrilus*) *gracilis* (Michaelsen, 1892) [syn. *pallida* Michaelsen, 1892; *gracilis* var. *metandra* Omodeo, 1973] is reported from Kenya, West Africa, and from Manaus, Brazil, Equador, Surinam Monserrat, St. Barts and Guayana, South America (Brown & Fragoso, 2007).

Dichogaster (*Diplothecodrilus*) *mundamensis* (Michaelsen, 1897) (syn. *Dichogaster mansfeldi* Michaelsen, 1915: 197) is known from Nigeria, the Canary Islands, and from Soa Tome Island (Cs. Csuzdi pers. com.), possibly by transportation. See description in Csuzdi (2000).

Dichogaster godeffroyi (Michaelsen, 1890) originally *Benhamia godeffroyi* [now = *Eutrigaster* (*Graffiona*) *godeffroyi*] from Haiti (Puerto Plata) had a New Zealand report that Michaelsen (1900: 355) doubted (see Blakemore, 2007; Csuzdi, 1997).

Dichogaster affinis (Michaelsen, 1890)

Fig. 1.15 *Dichogaster affinis* (a) ventral view showing (b) prostates with penial setae and

(c) spermathecae *in situ*, (d) prostomium, (e) dorsal dissection with gizzards, calciferous glands, saccular nephridia, prostates and intestinal typhlosole exposed, (f) lateral view (and a cocoon).

Fig. 1.16 *Dichogaster affinis*, ventral view of second specimen with spermathecae, prostates and gizzards *in situ* as in previous figure.

Benhamia affinis Michaelsen, 1890: 9, fig. 20. [Type locality Quilimane, Mozambique. Type in Hamburg Museum]; Michaelsen, 1897: 13.

Benhamia mexicana Rosa, 1891: 394; Eisen, 1895: 125 [From Durango, Mexico. Types in Vienna?].

Benhamia crassa Beddard, 1893: 681 , figs. 6,7. [Types at Kew obtained from Lagos, the type-locality (under ICZN, 1999: Art. 76.1.1). Type BMNH 1904:10:5:829].

Benhamia floresina Horst, 1893: 34, figs. 6-9. [From Sumatra, Flores and Timor. Types Leiden, 1801].

[?*Dichogaster curgensis* var. *unilocularis* Stephenson, 1931: 69. Type locality Lashio (and from Kutkai), northern Shan, Burma. Types in British Museum, 1930:5:9:15-16. Note: Gates (1972: 280) thought this a synonym of *D. curgensis* (= *D. annae*) and Csuzdi (1995: 103) has it as a syn. nov. there; although Csuzdi (1996: 357) puts it in synonymy with *D. affinis*, Csuzdi (2000: 59) again has it within *D. annae* where it probably belongs].

Dichogaster sinuosus Stephenson, 1931b: 74. [From Lalaw, Burma. Syntypes BMNH 1930:5:9:22-24].

Dichogaster sinicus Chen, 1938: 420, fig. 18. [From Hainan. Types?].

D. sinensis Chen, 1938: 421, legend for fig. 18. (?Nomen nudum pro *D. sinicus*).

Dichogaster affinis: Michaelsen, 1900: 345; 1903: 20; Gates, 1942: 128; Gates, 1972: 278 (syn. *sinuosus*); Blakemore, 1994; 2002; 2006.

Dichogaster (*Diplothecodrilus*) *affinis* : Csuzdi (1996: 357) (syn. *crassa, curgensis* var. *unilocularis, floresiana, mexicana, sinicus, sinuous*); 2000: 58 (syn. *mexicana, crassa, floresiana, sinuosus, sinicus*).

Distribution: Southeast Asia, e.g. India, Sri Lanka, Myanmar (Burma), Thailand (Gates, 1939; Julka, 1988; and pers. obs.), Sumatra (North Lampung), Vietnam (Thai, 2000); North, Central and South America [e.g. Chile (Zicsi, 2004), French Guayana (Cernosvitov, 1934), Manaus, Brazil (Righi, 1990), Honda, Colombia (Michaelsen, 1900), Port au Prince, Haiti (Michalsen, 1903), Equador, Bolivia, Mexico, Cuba, etc. (Brown & Fragoso, 2007), also Florida and Galapagos (Csuzdi, 1997: 37; 2000: 59)], West and East Africa (e.g. Lagos, Nigeria; Kenya), Seychelles (Ref., 2010), Canary

Islands (Talavera, 1992), Pacific Islands (Easton, 1984). This is the first record from Australia (Blakemore, 1994, 1999).

Locality: Brisbane in soil from Narayen (and Biloela). New records for Australia. Several specimens also obtained from Thailand (collected by Dr Sukaoto, identified R.J.B. 21.xii.2005) in YNU collection; Gates (1939) already recorded this species there.

Habitat: Clay soil in pots in glasshouse (cultivated clay soils); in regularly burnt forest in Thailand; Hairiah *et al* (2001) found it a widespread and persistant topsoil species.

Registration No.: Numerous ANIC specimens obtained from soil cores in a glasshouse.

Behaviour: Moderately active, if agitated exudes yellow coelomic fluid which has a distinctive smell, if stressed further a lashing response of the body is observed.

Length: 25-39 mm.

Width: 1-1.5 mm.

Segments: 107-140 with much secondary annulation after clitellum, intersegmental furrow 1/2 indistinct ventrally.

Colour: Pigmentless but anterior appears pinkish, the hearts and calciferous glands give the appearance of red and white 'collar', faintly iridescent sheen.

Prostomium: Epilobous: slight or marked V-shaped notch both dorsally (as furrow to 1/2) and ventrally on peristomium.

First dorsal pore: 5/6 (on clitellum only that in 13/14 visible)

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired on the ventrum; setae of 17 and 19 penial on porophores but not visible externally; (4:1:3:1:24:0.6).

Nephropores: Minute but exposed by ejecta on preserved specimens as being in four equally spaced rows lateral to d lines on each side.

Clitellum: Saddle shaped: 13-21 extends further dorsally.

Male pores: In tumid seminal grooves on 18 which run vertically from raised prostatic porophores on 17 and 19.

Female pores: Paired just anterior to setae a in raised pad on 14 which encompasses ab and reaches to 13/14-14/15.

Spermathecal pores: Two pairs in 7/8 and 8/9 in ab lines but closer to setae a.

Genital markings: Faint or distinct, mid-ventrally as eye-shaped translucent dishes in 7/8 and/or 8/9 or often just in 9/10 (or sometimes in some of 9/10-11/12 too?).

Septa: weakly developed and displaced posteriorly (from 5/6).

Dorsal blood vessel: Single, continuous onto pharynx (ventral vessel bifurcates into hairpin loops on each side under gizzards).

Hearts: 11-12 (or 13?).

Gizzard: Co-joined pair, white with sheen, muscular; typically displaced posteriorly to 6 and 7 or 8.

Calciferous glands : Three pairs of white reniform glands surrounding oesophagus in 15-17, the anterior pair smaller.

Intestine origin (caeca, typhlosole): Widens appreciably in 17 after calciferous glands, dorsal typhlosole after about 21.

Nephridia: Saccular meroic in four rows on each side clearly visible from anterior through clitellar segments and posteriorly, (containing fat reserves?).

Male organs: Testes/funnels iridescent in both 10 and 11, (seminal vesicles vestigial in 11 and 12?).

Ovaries: A pair in 13, palmate with 3 or 4 egg strings.

Prostates: A pair confined in each of 17 and 19 with sheaths of the penial setae close to the short muscular ducts.

Spermathecae: Two pairs, small each with wide duct bearing midlength on anterior wall a short-stalked bulbous iridescent diverticula and terminating in a spherical or deformed yellowish ampulla.

Gut contents: Fine soil material and few small grits.

Notes: When preserved, rows of external ejecta corresponding to the position of the saccular nephridia internally were often observed, indicating exonephry. Specimens were recovered from clay soil cores obtained from Narayen and kept in the glasshouse in Brisbane for many months with constant watering. The numbers recovered were very high and sometimes equivalent to a population of more than 7,000 m^{-2}. High fecundity: when re-introduced into heat sterilized cores of both sandy and clay soils the populations increased by factors of 10 over six months and were associated with markedly increased yields of plants (Blakemore, 1994: Fig lower rhs cf. control lower lhs; ; 1997; 2007).

Dichogaster annae (Horst, 1893)

Benhamia annae Horst, 1893: 32, tab. 2, figs. 1-5. [From Cameroon (and Java). Types in Leiden: 1798]; Michaelsen, 1897: 15.

Benhamia parva Michaelsen, 1896: 31, tab. 1, figs. 9-11. [From Duki-Ufer in Central Africa, and reported from India (?possibly a mistake for *Dichogaster parvus* Fedarb, 1898). Types Hamburg 297 and London 1895:9:3:3]. [Non

Moniligaster parva Bourne, 1894 (?= *Drawida barwelli*); nec *Dichogaster parvus* Fedarb, 1898 (= *Eudichogaster parva*) from Dehra Dun, east India. Note: this erstwhile secondary homonym appears to have been overlooked in the past but is now resolved by synonymy and generic reallocation].

Benhamia travancorensis Fedarb, 1898: 433. [From Travancore, India. Type BMNH 1904;10.5.664]. [Non *Gordiodrilus travancorensis* Michaelsen, 1910 (= *Gordiodrilus elegans*)].

Dichogaster curgensis Michaelsen, 1921: 54. [Type locality Moonad, Coorg, South India. Types in Hamburg Museum, 9152-3].

?*Dichogaster curgensis* var. *unilocularis* Stephenson, 1931: 69. [Type locality Lashio (and from Kutkai), northern Shan, Burma. Types in British Museum, 1930:5:9:15-16]. [Note: Gates (1972: 280) thought this a synonym of *D. curgensis* (= *D. annae*) where Csuzdi (1995: 103) has it as a syn. nov. and Csuzdi (1996: 357) has it (erroneously) in synonymy with *D. affinis*; but Csuzdi (2000: 59) again has it within *D. annae*].

Dichogaster cheranganiensis Cernosvitov, 1938: 298. [Types London and Pairs].

Dichogaster silvestris cacaois Righi, 1968: 376. [Type Sao Paulo, 6].

Dichogaster servi Righi & Ayres, 1975: 311. [From Brazil and Costa Rica. Type Manaus, 3].

Dichogaster curgensis: Gates. 1972: 280 [syn. *curgensis* var. *unilocularis* (but see *D. affinis*)].

Dichogaster (*Diplothecodrilus*) *annae*: Csuzdi, 1995: 112; 1996: 357 (syn. *silvestris cacaois* Righi, 1968, *cheranganiensis* Cernosvitov, 1938, *curgensis* Michaelsen, 1921, *servi* Righi & Ayres, 1975, *Benhamia parva* Michaelsen, 1896, *travancorensis* Fedarb, 1898); Csuzdi, 2000: 59 (syn. *travancorensis, curgensis, curgensis* var. *unilocularis, cheranganiensis, silvestris cacaois, servi, parva*).

Taxonomic Note: Gates (1972: 278) noted two of the taxa recorded from India, *Dichogaster parva* (Michaelsen, 1896), and *D. travancorensis* (Fedarb, 1898) - that was claimed to have calciferous glands in 14-16, were inadequately characterized although Csuzdi (1996: 107) inspected types and found both to be synonymous with *D. annae*. The name *curgensis* (sometimes misspelt "*curagensis*" e.g. Reynolds & Cook, 1976: 185) was made type-species of the sub-genus *Diplothecodrilus* by Csuzdi (1996: 355).

(The following description taken from authors listed above augmented by pers.obs.).

Distribution: *Dichogaster annae* (Horst, 1893) is known from West and East Africa

[e.g. Cameroon – Birang *et al.* (2004: *Pedobiologica*, 47); Ghana, Uganda, and Kenya - Csuzdi (2000)], Java, India especially in the South, Myanmar, South and Central America: e.g. Venezuela (e.g. Righi, 1989), Columbia (Csuzdi, 1994: 67; Feijoo *et al.*, 2004), Csuzdi (1994: 68) shows the former *D. servi* synonym widespread in Brazil and also in Cuba (Csuzdi & Zicsi, 1991), Costa Rica [previously reported as "*D. parva*" from Sao Paulo, Brazil by Righi (1968; 1999)], and from Latin America: e.g. Ecuador, Mexico, Guatemala. The former *D. curgensis* Michaelsen, 1921 synonym was from India and Myanmar, the species being exotic to both (Gates, 1972). Also recorded by Blakemore (1999) from NSW as a new record from Australia, initially as *D. curgensis* - now corrected to *D. annae*.

Locality: Taree, NSW; collected by M. Ford in compost from cattle manure, June, 1997 and sent to the author for identification.

Habitat: Compost.

Registration No.: Author's collection in Canberra, Australia.

Behaviour: ?

Length: 21-75 mm.

Width: 1-2 mm.

Segments: 90-110; first intersegment faint.

Colour: Unpigmented cf. present specimen a dark greenish-brown with dark mid-dorsal line, pale ventrum and buff clitellum.

Prostomium: Closed epilobous, (tongue not narrowing posteriorly in current specimen).

First dorsal pore: In region of 4/5-5/6; 5/6 in current specimen.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment; ventral couples of 18 missing; those of 17 and 19 replaced by penial setae.

Nephropores: ?

Clitellum: Annular though often thinner in aa lines, in 12,13-20.

Male pores: On equator of 18.

Female pores: Paired, at sites of missing a setae (Michaelsen), or just anterio-median to setae a (Stephenson), or just ventral of a setae on 14 (current specimen).

Spermathecal pores: Close to setal a lines in 7/8 and 8/9; or indistinct and possibly in mid ab (current specimen).

Genital markings: None.

Septa: 5/6/7/8 present and thickened; to intestinal segments but not muscular.

Dorsal blood vessel: Single.

Hearts: 9,10-13; or 10-12 in current specimen.

Gizzards: In 6 and 7 (always?).

Calciferous glands : Three pairs in 15-17.

Intestine origin (caeca, typhlosole): 20, deep typlosole from 25 (current specimen).

Nephridia: Avesiculate meroic with about 6 saccular nephridia per segment (pers. obs.).

Male organs: Testes/funnels in 10 and 11 (small, free and iridescent); seminal vesicles lacking or small in 11 and/or 12; perhaps vestigial in 12 in current specimen.

Ovaries: In 13; as largish fan-shaped egg-strings in current specimen.

Prostates: Two pairs in 17 and 19, tubular; penial setae present that are as long as gland in present specimen.

Spermathecae: Paired in 8 and 9, each with slender duct longer than narrow ampulla, short diverticulum at ental end of duct with seminal chambers internally; the diverticulum joins the ampulla (Stephenson) or the duct (Michaelsen), or, in current specimen, the junction of ampulla and duct; moreover the seminal bulb is bifid.

Gut contents: ?

Remarks: Michaelsen (1921) thought his *Dichogaster curgensis* (= *D. annae*) was possibly a junior synonym of the inadequately (and perhaps erroneously) characterized *D. travancorensis* (Fedarb, 1898) which itself is also similar to *D. modiglianii*. Differences of *D. curgensis* were the presence of septa 5/6/7/8; gizzards in 6 & 7 (rather than 7 & 8); and the spermathcal shape. The above synonymy of *D. annae* is according to Csuzdi (1996: 357; 2000: 59).

Dichogaster annae (Horst, 1893), reported as its junior synonym *D. curgensis* Michaelsen, 1921, has been indicted as a serious pest of rice terraces in the Philippine Cordilleras, e.g. by Barrion & Listinger (1997), cf. *Eukerria saltensis*.

Dichogaster bolaui (Michaelsen, 1891)

Fig. 1.17 *Dichogaster bolaui* Biloela specimen (a) ventral view (pharynx everted), (b) spermathecae (c) paired gizzards and calciferous glands, (d) lateral view.

Fig. 1.18 *Dichogaster bolaui*, ventral and lateral views of second specimen with spermathecae, prostates and gizzards *in situ*.

Benhamia bolavi (corr. *bolaui*) Michaelsen, 1891: 9, figs. 1,2. [Type locality Bergedorf near Hamburg, from fermenting bark in a tannery. Type thought to be in the Hamburg Museum was reported by Csuzdi (2000) as BMNH: 1924:3.1.244];

Eisen, 1895: 125; Michaelsen, 1897: 15 (syn. *palmicola, octonephra*).

Benhamia malayana Horst, 1893: 35, figs. 10-13. [Type Leiden, 1794].

Benhamia octonephra Rosa, 1895: 2. [Type Hamburg, 4501].

Benhamia palmicola Eisen, 1895: 125, figs. 44-46, 53-54. [From Baja and Tepic, Mexico. Types Hamburg, 279].

Benhamia rugosa Eisen, Eisen, 1895: 126, figs. 56-63. [From California hothouse].

Benhamia bolavi pacifica Eisen, 1900: 209, figs. 68-93. [From Honolulu].

Dichogaster bolaui decanephra Michaelsen, 1915: 191. [Type Hamburg, 8436-7 and Paris. Note: misspelt "boloui decanephra" in Reynolds & Cook (1976: 930)].

Benhamia lageniformis Friend, 1916: 262. [From Botanic Gardens, Oxford. Types lost].

Dichogaster bolaui malabaricus Stephenson, 1920: 257. [Types in London].

?*Dichogaster hatomaana* Ohfuchi, 1957: 259. [From Hatoma-jima, Ryukus. Types unknown]. [Thought to be *D. saliens* by Easton (1981: 46)].

Dichogaster bolaui: Michaelsen, 1900: 340 (syn. *octonephra*, *palmicola*, *bolavi pacifica*); Stephenson, 1931b: 64; Stephenson, 1933: 934 (syn. *malayana*); Gates, 1942: 129; Gates, 1972: 279; 1982: 68.

Dichogaster (*Diplothecodrilus*) *bolaui* : Csuzdi, 1996: 358 [syn. *bolaui* var. *decanephra, bolaui* var. *malabaricus, bolaui pacifica, hatomaana, lageniformis, malayana, octonephra, rugosa*]; 2000: 60 (syn. *bolaui* var. *decanephra, bolaui* var. *malabaricus, bolaui pacifica, lageniformis, hatomaana, malayana, octonephra, rugosa*).

Taxonomic Note: the *D. bolaui malabaricus* morphs have paired spermathecal diverticula according to Stephenson. Name sometimes misspelt "*boulai*" (Ref.).

Distribution: Home range thought by Csuzdi *et al.*, (2007: fig. 1) to be in central coastal East Africa e.g. in Kenya and bordering its current distribution there is broader (e.g., Cameroon, Kenya, Oman, Madagascar, Seychelles, Bulawayo Rhodesia), also Asia (e.g. China, Philippines), India, Bangladesh, Americas e.g., Mexico, Baja-California, USA, Hawaii, Florida, Georgia - Csuzdi (1997: 38), French Guayana (Cernosvitov, 1934), Venezuela, Paraquay, Argentina, Brazil, Colombia, Panama, El Salvador, Curacao, Bonaco - a little island in the Bay of Honduras, etc. in West Indes (Gates, 1972: 279) e.g. Belize, Costa Rica, Cuba, Dominican Republic, Haiti, Honduras (Rodriguez, 1999) and Jamaica, Galapagos - Csuzdi (2000) and Santa Rosa, San Cruz, Galapagos Islands (collected M. Mantilla/M. Nakamura, 1994-VII-4 – pers. obs. in 2001 and **new record**); Europe including Scandinavia [reports from pools of Botanic Gardens, Oxford and

sewage systems in Stockholm and Finland, and from drains of a heated indoor swimming pool in Cork, Ireland by Rota & Schmidt (2006) although they are wrong to claim this as first record from the British Isles cf. Friend (1916); Oceania; Australasia e.g. Christmas Island (Gates, 1935) and current reports herein, Papua New Guinea - Csuzdi (1997: 38). Pan-tropical, a very common worm. Probably the most widely distributed species in Vanuatu (Lee, 1981: 566). Stephenson (1931a: 38,64) obtained two specimens from the Australian Institute of Tropical Medicine from Kavieng, New Ireland, "*washed out of the vagina of a native woman*" but he found "*no reason to assume a prolonged sojourn of the worms in the vagina*". Recently (Oct., 2012) a specimen was also identified from the vagina of a Korean worman although its method of ingress is unknown (Blakemore *et al*. 2012).

Locality: Brian Pastures (Gayndah), Mundubbera, Biloela, Brisbane, Samford, Mt Cotton, Eurong Resort - all new records for Qld; Alstonville, NSW (**new record**). Santa Cruz, Galapagos (**new record**), Korea (**new record**).

Habitat: Soil under crops, pasture, citrus and hay; in glasshouse pots; samples collected at Eurong Resort, Qld sent by Dean Cameron of Domus (composting toilets) were from the beach and from septic tanks at Maleny. Lee (1981) described samples from river terrace, leaf bases, rotten logs, epiphytes, litter under *Ficus* trees, soil in coconut plantation, school yard, "*White grass*", and rainforest soil. There are now two vagina reports as noted above.

Registration No.: Numerous specimens collected by the author in ANIC collection and Korean specimen in NIBR.

Behaviour: Exudes a clear fluid and rapidly lashes body when irritated.

Length: 20-40 mm.

Segments: 78-97, intersegmental furrow 1/2 faint, some secondary annulation in anterior segments, fine longitudinal striations posterior to clitellum frequently observed (see *D. saliens*).

Colour: Anterior dorsum with brownish pigment, clitellum yellowy otherwise only faintly pigmented. Dark dorsal line visible as are the pale internal calciferous glands.

Prostomium: Closed epilobous, small and anteriorally placed so not extending much backwards - often everted on preservation to expose a large flat anterior pharyngeal pad.

First dorsal pore: 5/6 (occluded?), 6/7 and continuous thereafter, including on clitellum.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment, small and closely paired on ventral surface; ab of 17 and 19 modified as penial setae with common opening at prostate pore

and visible externally; ab (and c?) setae of 14 sometimes lacking; (4:2:5:2:30:0.3).

Nephropores: Minute.

Clitellum: 13,14-18,19,20.

Male pores: In-curving or convexed seminal grooves on 18 between prostatic pores on 17 and 19.

Female pores: Single, central and almost equatorial on tumid pad that encompasses ab couples of 14.

Spermathecal pores: Close to setal a lines of 7/8 and 8/9.

Genital markings: None.

Septa: Anterior septa missing or reduced, those of 5/6 thin and dorsally displaced and easily torn (this may account for reports of variations in precise location of organs).

Dorsal blood vessel: Single and continuous onto the pharynx.

Hearts: 10-12.

Gizzards: Muscular pair in 6 and 7, displaced posteriorly to appear in segments 8 and 9 (obscuring the spermathecae).

Calciferous glands: Three pairs of whitish reniform calciferous glands in 15-17 (displaced one or more segments?).

Intestine origin (caeca, typhlosole): Intestine widens in 17, (typhlosole not seen).

Nephridia: Around the clitellar segments large saccular meronephridia in 4 rows on each side.

Male organs: Testes/funnels in 10 and 11, iridescent.

Ovaries: In 13.

Prostates: Two pairs in 17 and 19 (although the latter pair appears to occupy 18).

Spermathecae: Two pairs in 8 and 9, each with tapered duct bearing small, lobed and anteriorally directed iridescent diverticulum; ampulla spherical (bent?).

Gut contents: Fine soil.

Notes: Collected from DPI Brian Pastures near a hay barn; Mundubbera in irrigated sandy soil in an orchard; Biloela, in low numbers in cultivated field; from Samford in clay soil under pasture where one specimen was being attacked by a bright cobalt blue planarian, and from besides the South Pine River; and from Mt. Cotton UQ farm under *Leaucaena leucocephala* also as incidental inclusions to worm stock cultures maintained in the glasshouse in Brisbane. Often found dead beside plant pots after watering in homes in Brisbane.

This small species appears to be ubiquitous in many sites but does not attain

especially high density. Edwards & Lofty (1977: 63) reported parthenogenic morphs although some current specimens appear sexual.

Dichogaster modiglianii (Rosa, 1896)

Benhamia modiglianii Rosa, 1896: 510, figs. 1a-b. [Type locality Padang, Sumatra. Type in Genoa Museum, 44050].

Benhamia papillata Eisen, Eisen, 1895: 126. [From Tepic, Mexico. Types?].

Benhamia kafuruensis Michaelsen, 1896: 34. [Types Hamburg, 298 and Berlin (lost)].

Benhamia nana Eisen, 1895: 125. [From San Blas, Mexico. Types?]; Eisen, 1900.

Benhamia papillata var. *hawaiiensis* Eisen, 1900: 212. [Honolulu and Somoa].

Dichogaster doveri Stephenson, 1931a: 276. [Type locality in ditch, museum compound, Selangor, Kuala Lumpur. Types in British Museum: 1933:2.14.60-61].

Dichogaster modiglianii: Stephenson, 1931b: 65;Stephenson, 1933: 934 (syn. *doveri*); Gates, 1942: 130 (syn. *doveri*); Gates, 1972: 280; Julka (1988: 110) (syn. *papillata, papillata hawaiiensis, doveri*).

Dichogaster (Diplothecodrilus) modiglianii : Csuzdi, 1995: 114; 1996: 358; 2000: 65 (syn. *doveri, kafuruensis, nana, papillata, papillata var. hawaiiensis*).

(The following description taken from various authors in the above synonymy).

Distribution: Ghana; Kenya; Dafur, Sudan (Csuzdi, 1997; 2000); Angola (Julka, 1988: 113); Madagascar (Ref.); Sumatra; Myanmar; Calcutta, Bengal, Bangladesh, Meghalaya, Orissa, and Andaman & Nicobar Islands, India; Lahore and Kamra in Attock District, Pakistan; Bangladesh; Malay Peninsula; Vietnam; Philippines; New Caledonia; New Britain; New Hebrides (=VanuaTu); Papua New Guinea; USA (Florida - Csuzdi, 1997); Hawaii; Colombia; French Guiana; Bolivia, Brazil; Venezuela; Peru; ?Equador; Mexico (Julka, 1988), and Cuba (Rodriguez, 2004). Original home in Africa (Gates, 1972). The synonyms, *Dichogaster papillata* (Eisen, 1896) and its variety *D. papillata hawaiiensis* (Eisen, 1900), are from Mexico, 'Belgian Congo', San Francisco (believed introduced from Hawaii and Samoa), and Christmas Island south of Java [Australian Territory - e.g. Gates (1935b); Michaelsen (1935a)]. New Zealand? – this from a report by Ude (1905: 495) as reported in Thomson (1922: 358) who says: "*This species has been reported to me, but I have failed to record by whom, as occurring in New Zealand. Dr Benham informs me that the only record of a Dichogaster in this country, rests on a sttement by Ude (1905), that an unnamed species, allied both to D. modigliani and to D. malayana,*

Horst, was gathered "at Oripi Bush, Tauranga," by a German traveller. He records it merely as Dichogaster sp. As these worms come from Sumatra and the Malay Archipalago, he considers it likely that the tickets of localities got mixed up." On this last point I cannot agree and think that it is entirely possible *Dichogaster* occurs in NZ, but the actual species found is not clarified.

Locality: Specimen #S22 from Kahariam organic farm, Batangas in rice field collected by RJB and RO 14th Aug., 2013 providing mtDNA sample P9 (see results below).

Habitat: Found in soil rich in humus and in trees; drains; sea shore.

Registration No.: N/A.

Behaviour: ?

Length: 20-60 mm.

Width: 1-2 mm.

Segments: 76-120.

Colour: Grey or unpigmented.

Prostomium: (Pro-?)epilobous, tongue narrowed posteriorly reaching to 1/2 (as in *D. affinis* and *D. saliens*).

First dorsal pore: In region of 4/5 or 5/6.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment (aa = bc).

Nephropores: ?

Clitellum: Annular but appears saddle-shaped as it is often thinner in aa lines in 13-20.

Male pores: On equator of 18 in nearly straight seminal grooves.

Female pores: Paired, just median or posteromedian to setae a on 14.

Spermathecal pores: Close to setal a lines in 7/8 and 8/9.

Genital markings: None.

Septa: 5/6/7/8 often missing or reduced.

Dorsal blood vessel: Single.

Hearts: 9,10-13; stated to have last hearts in 12 by Julka (1988; 111).

Gizzards: In 7 and 8 (always?); stated to be between 4/5 and 7/8 by Julka (1988: 111).

Calciferous glands: 15-17.

Intestine origin (caeca, typhlosole): 19, dorsal typhlosole present from 22,23 to 78 or 80; small paired lateral typhlosoles from 23,24 for about five segments.

Nephridia: Meroic, from 20 or 21, discoid often in four rows per side.

Male organs: Testes/funnels in 10 and 11, those in 11 in testis sacs formed by septa 10/11/12; seminal vesicles lacking or small in 12.

Ovaries: In 13, (ovisacs possibly small in 14).

Prostates: Two pairs in 17 and 19, tubular with ducts slenderer than the glands; penial setae present.

Spermathecae: Paired in 8 and 9, each with bulbous duct longer than ampulla and bearing about mid-length a short diverticulum with a small, iridescent, bulb. Gates (1942) recognized clumps of rod-like structures in several spermathecal ampullae that may be crystals of fragments of the partners' penial setae that have broken off.

Gut contents: ?

Remarks: *Dichogaster modiglianii* (Rosa, 1896) is similar to *Dichogaster affinis* differing mainly in its lack of genital markings. Gates (1942) noted mistakes in Stephenson's description of *D. doveri* specimens that actually complied with *D. modiglianii*.

DNA: >P9 (641bp) 14/XI/13 Kahariam rice near gate: id *Dichogaster modigliani*.
Sequence:
TCGGAGTATGAGCCGGAATAATTGGAGCAGGTATAAGACTACTAATTCGAATTGA
ATTAAGACAACCGGGAGCATTCCTAGGAAGGGACCAACTATACAATACAATTGTA
ACGGCACACGCCTTTCTAATAATCTTTTTCCTAGTAATGCCAGTATTTATTGGGGG
GTTTGGAAATTGACTCCTCCCCCTAATATTAGGAGCACCAGATATGGCATTCCCC
CGATTAAATAATCTAAGATTTTGATTATTACCCCCATCTTTAATCTTACTTGTATCA
TCTGCAGCCGTGGAAAAGGGCGCAGGTACAGGATGAACAGTATACCCACCACTA
GCAAGAAACCTAGCTCATGCAGGACCATCAGTAGACTTAGCAATCTTTTCCCTAC
ATTTAGCAGGTGCTTCATCTATTCTAGGAGCAATTAACTTTATTACAACAGTAGTT
AACATGCGATGATCTGGCCTACGACTAGAACGAATTCCACTATTTGTGTGAGCAG
TAGTAATTACAGTAGTTCTACTCCTTTTATCATTACCAGTTTTAGCCGGAGCCATC
ACCATACTTCTAACTGACCGAAACCTAAACACATCATTCTTTGATCCAGCGGGTG
GGGGGGATCCAATTCTATATCAACACCTATTC
Blast result:
Most recent: 100% MN179625 and MN662340 (*D. modigliani* from India). Previously - *Acanthodrilidae sp.* (GU013989.1), 87%. See also Blakemore (2016: fig. 1 phylotree).

Dichogaster saliens (Beddard 1893)

Fig. 1.19 *Dichogaster saliens*, Samford specimen (a) ventral view with (b) prostate and penial setae, and (c) spermathecae *in situ*; (d) dorsal dissection; (e) lateral view.
Fig. 1.20 *Dichogaster saliens*, ventral view of second specimen.

Microdrilus saliens Beddard, 1893: 683, figs. 8, 13; *M. asiaticus* (laps.) Beddard, 1893: 706. [Type-locality not designated, but specimens were found by Mr Thistleton Dyer at Kew Gardens in soil from Singapore, Java and Penang (see ICZN, 1999: Art. 76.1.1). Type material unknown, possibly in British Museum?].

Dichogaster crawi Eisen, 1900: 228, figs. 82-94. [From Honolulu in roots of plants

receirved at San Francisco. Types missing]; Michaelsen (1916: 19 – from Fitzroy River, Noonkanbah, W.A.; also California: San Franciso and Del Monte, Honolulu Hawaii, and Pietermaritzburg Natal South Africa).

Dichogaster saliens: Michaelsen, 1900: 343; Michaelsen, 1935b: 102 (syn. *crawi*); Stephenson, 1923; 1931a: 65 (syn. *crawi*); Gates, 1972: 281; 1982: 69.

Dichogaster (Diplothecodrilus) saliens : Csuzdi, 1996: 358; 1997: 41 ("saliensis" lapsus; 2000: 66 (syn. *crawi*).

Distribution (mainly from Gates, 1972: Asia e.g., India (with a recent report from western Himalayas), Bangladesh, Java, Sumatra, Singapore, Penang, Vietnam; Taiwan (Shen & Tsai, 2007), Americas (e.g. USA: California, Florida; Hawaii, Galapagos), from Sao Paulo, Brazil by Righi (1968) and reported as common in agricultural soils in Tabasco, Mexico; from Cuba etc. e.g. by Rodriguez (2004) also Argentina, Peru, Bolivia, Venezueala, etc. (Brown & Fragoso, 2007); Africa (e.g. Uganda, Ghana, Swaziland), Pietermarizburg, SA (Michaelsen, 1916: 19); Madagascar (Ref.); Europe (Scandanavia - one report from drains in Stockholm – see also *D. bolaui*); Australia, i.e., pan-tropical but possibly at higher elevations. This record of *D. saliens* proper from continental Australia by the author was thought the first although it was reported from Christmas Island (Australian territory) south of Java (by Gates, 1935); however the reference by Michaelsen (1916: 19) of *D. crawi* synonym from Fitzroy Falls, Noonkambah, WA had unfortunately been overlooked previously.

Locality: Brisbane, Samford, Mt. Cotton - new records, Qld.

Habitat: In glasshouse pots; soil under trees, crops and pasture.

Registration No.: Numerous specimens.

Behaviour: Lashes body vigorously when irritated (Beddard, 1893: 683 and pers. obs.).

Length: 25-55 mm (cf. Gates, 1972, 17-70).

Width: 1.5-2.5 mm.

Segments: 105-118 (cf. Gates, 1972, 73-120) intersegmental furrow 1/2 faint, some secondary annulation and, occasionally, fine longitudinal striations after clitellum (as seen in *D. bolaui*).

Colour: Anterior dorsum with dark brown pigment, clitellum copper-brown. Dark dorsal line visible, (cf. Stephenson, pinky flesh-colour; Gates, unpigmented).

Prostomium: Closed epilobous reaching almost to 1/2.

First dorsal pore: (3/4?) 4/5 or 5/6 and continuous thereafter, except on other than the first and last intersegments on clitellum.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment, small and closely paired on ventral surface; ab of 17 modified as penial setae with common opening at prostate pore and visible externally; ab setae of 14 lacking?; (3.5:1.0:3.5:25:0.65).

Nephropores: Minute?

Clitellum: Mostly saddle-shaped 13-19,20, (cf. Gates, annular but thinner in aa).

Male pores: Not definitely found (posterior to the prostatic pores), within closely paired raised porophores in 17 that slope backwards in seminal grooves to the equator of 18.

Female pores: Paired median to setae a, central and equatorial on slightly tumid pad that encompasses both ab couples of 14.

Spermathecal pores: Close to setal a lines of 7/8 and 8/9.

Genital markings: Sometimes a small mid-ventral circular disk in 15/16.

Septa: Septa from 1/2 fairly thick, 5/6/7/8 missing or reduced.

Dorsal blood vessel: Single and continuous onto the pharynx, ventral blood vessel double, no sub-neural vessel.

Hearts: Last hearts in 12 (and close to septum 12/13 thus appearing to be in 13).

Gizzards: Preceded by a 'crop' in 6, muscular in 7 and 8 (?), displaced posteriorly to appear in segments 9 and 10.

Calciferous glands: Three pairs of whitish digiform calciferous glands in 15-17, the anterior pair smallest, the posterior pair without external lamellae.

Intestine origin (caeca, typhlosole): Intestine widens in 17; (dorsal and lateral typhlosoles present).

Nephridia: Meroic; saccular in 4 rows on each side at least around clitellar segments.

Male organs: Testes/funnels iridescent in 10 and 11; seminal vesicles small in 11 and 12.

Ovaries: Small rosettes in 13, (ovisacs in 14).

Prostates: Single pair in 17 each a long tubular gland to thinner muscular ducts with a small gland (always?) and penial setal sheaves at the ectal end. Prostates overlie serpentine vasa deferentia that probably open nearby.

Spermathecae: Closely paired in 8 and 9, each with tapered duct bearing small, pendulate digiform anteriorally directed, diverticulum (occasionally iridescent); ampulla spherical, flattened and bent almost at right angles.

Gut contents: Fine soil.

Notes: Collected from Samford in clay soil under pasture and from alluvial sandy soil beside South Pine River, where it was found in appreciable numbers in association with various other lumbricids, and native, and exotic megascolecids. From Mt. Cotton under

leucaena. In the glasshouse in Brisbane, large numbers of *D. saliens* were extracted from clay soil from Narayen and these were added to a worm-free sandy soil which subsequently demonstrated greatly increased plant yield.

Two forms seem to be encountered, a smaller morph obtained from glasshouse pots and a substantially larger morph collected in the field: dissection failed to find features of differentiation other than size so they could possibly represent age classes.

Genus ***Eutyphoeus*** Michaelsen, 1900

Typhoeus Beddard, 1883 (nom. preocc. *Typhoeus* Leach, 1815, Coleoptera); *Typhaeus* : Beddard, 1888: 111, 117; 1895 (illegal. emend.); Benham, 1890: 122; *Eutyphoeus* Michaelsen, 1900: 322 (nom. nov.); Gates, 1959: 247; 1972: 281.

Type-species: *Typhoeus orientalis* Beddard, 1883: 219 from Calcutta.

Diagnosis: Octochaetidae with lumbricine setae. Dorsal pores present. Clitellum 14-16. Biprostatic, pores of tubular prostates open just in front of male pores on 17. Bithecal, pores at 7/8. Oesophageal gizzard single (belonging to 6 but appearing somewhere between 5/6-8/9). Calciferous glands one pair intramural in 12. Intestinal origin behind 15. Caeca absent. Hearts 10-13. Dorsal blood vessel single. Meroic, avesiculate.

Distribution: There are approximately 69-74 nominal species (Ref1, Ref2 with several synonyms) found from Myanmar into India and Pakistan through to the Gangetic plains and west through Himalayas to beyond Nepal. Species such as *E. foveatus* (Rosa, 1890) and *E. peguanus* (Gates, 1925) sub-species are believed transported within and adjacent to Myanmar. A record for the genus in Sri Lanka [possibly for *Eutyphoeus levis* (Rosa, 1890) (corr. from "*laevis*") from Burmah and Ceylon - see Michaelsen (1900: 323)] was considered erroneous by Gates (1972: 282). *Eutyphoeus nicholsoni* (Beddard, 1901: 195) (originally as *Typhoeus nicholsoni*; syn *Eutyphoeus khani* Michaelsen, 1907: 233 from India) was in soil imported to Kew Gardens. *Eutyphoeus gammiei* (Beddard, 1888) (syns. *chittagongianus, koboensis, magnus*) and *Eutyphoeus waltoni* Michaelsen, 1907 (syns. *bengalensis, ibrahimi* and sometimes misspelt "valtoni" or "waltonii") apparently have natural wide distributions. *Eutyphoeus nepalensis* Michaelsen, 1907 is from Nepal and Faisalabad, Pakistan [Ref]. Paliwal & Julka (2005) give extensive distribution of some *Eutyphoeus* species in western Himalayas.

Only the type is briefly diagnosed here as representative as Gates and other

workers (e.g. Stephenson, 1923; Julka, 1988) treat Indian taxa in more detail.

Notes: Bahl & Lal (1933) and Gates (1959) describe in detail the paired dorsal 'hepato-pancreatic' intestinal glands that occur in about 5 or 6 segments around 79-83 (corresponding to the terminal of the intestinal typhlosole where it expands in size greatly) each set with minute openings into the gut and lying on either side of and beneath the dorsal vessel in most, if not all, *Eutyphoeus* sp. in which they were sought. Although these authors detected presence of a 'tryptic' protease enzyme, these glands may also function to culture microbes (as with intestinal caeca and convoluted typhlosoles, *vide intra*).

All known *Eutyphoeus* species are deep burowing and inactive for most of year. They are biparental, bioluminescent and geophagous. Bahl (1934) thought one species was a surface feeder; but most are claimed to produce tower-like castings (Gates, 1972: : 227, 282) cf. *Tonoscolex birmanicus* Gates, 1927: 609 that is also a tower-builder.

Eutyphoeus orientalis (Beddard, 1883)

Typhoeus orientalis Beddard, 1883: 219, fig. 1,2,4,9-12. [Types?].

Typhaeus orientalis : Beddard, 1888: 117, fig. 2.

Eutyphoeus orientalis : Michaelsen, 1900: 322.

Distribution: India - Calcutta, Rajshahi, Bengal, Dehra Dun, etc.; Bangladesh, Pakistan, Faisalabad (Ref.).

Diagnosis: Length 100-250 mm, diameter 4-12 mm, ca. 200 segments. Dorsal pores present behind clitellum. Setae lumbricine paired, all ventral. Three pairs of genital papillae, intersegmental, in front of the male pores, another pair on 18/19, sometimes on 20/2. Intestinal caeca starts around 34. Metandric. Spermathecal diverticula paired, median and lateral. Penial setae present. Intestinal glands present (Bahl & Lal, 1933).

Notes: Beddard (1883) redescribed *Megascolex affinis* (Perrier) [but Beddard's description actually was of *Metaphire posthuma* (Vaillant, 1868) according to Stephenson (1923: 309)], *Perichaeta armata* Beddard, 1883 [= *Lampito mauritii* Kinberg, 1867 according to Stephenson (1923: 259)], and *Typhoeus orientalis* (= *Eutyphoeus orientalis*), all of which he said were found in the neighborhood of Calcutta beneath (tower-like) castings "*precisely similar to those figured and described by Mr Darwin* [1881] *in his work on Earthworms*"; see Bahl [Ref].

Genus ***Lennogaster*** Gates, 1939: 186.

Type-species: *Eudichogaster yeicus* Stephenson, 1931.

Diagnosis: Lumbricine. Acanthodriline. Gizzards, two in 5-6, calciferous glands three in 10-13. Meroic.

Distribution: India (from northeast through Gangetic plain to lower western Himalayas; Myanmar; Bangla Desh. Perhaps the only peregrine is *Lennogaster pusillus* known from India and from Sumba Island, Indonesia. It is briefly diagnosed below.

Lennogaster pusillus (Stephenson, 1920)

Eudichogaster pusillus Stephenson, 1920: 252, figs. 56-57; 1923: 418. [From Saugor (Sagar), Madhya Pradesh, India. Types BM 1933:5:25:346-7].

Eudichogaster barkudensis Stephenson, 1921: 765, figs. 12-13; 1923: 408. [From Barkuda Island (known as Honeymoon Isl.), Chilika Lake, Orissa. Types ZSIC W 564/1; BM 1925:5:12:11].

Lennogaster pusillus : Gates, 1972: 306; Julka, 1988: 252, figs. 297-300 (syn. *barkudensis*).

Distribution: India: Uttar Pradesh; Madhya Pradesh; Himchal Pradesh; Karnaka; Orissa; Garhwal (Himalayas); Jammu (Ref.). Also from Sumba Island south of Flores, Indonesia by Gates (1972: 306) although this locality appears to have been overlooked by Julka (1988: 252). *Lennogaster pusillus* was found in compost at Indore MP, the site of Sir Alfred Howard's organic farming research station along with *Amynthas alexandri*, *Metaphire houlleti* and *Eudrilus eugeniae* (RJB pers. obs. 20th March, 2016).

Diagnosis: Length 20-68 by 1 mm. 100-132 segments. Proepilobous. First dorsal pore 11/12/13. Clitellum 13-16,17. Spermathecal pores on 8 anterior to a lines. Male and prostatic pores paired in 17 in seminal grooves near 17/18. Penial setae present. No copulatory setae. Genital markings absent. Gizzards, two in 5-6, calciferous glands three in 10-13. Typhlosole present. Proandric but with male funnels also in 11. Prostates one pair in 17. Spermathecae in 8 each with tubular ampulla and small, almost sessile diverticulum near the exit; sometimes diverticulum absent (overlooked?).

Notes: Gates (1945: 252) mistakenly describes extra set of spermathecae in segment 9.

Habits and Ecology: A litter species found in leaf litter, middens, compost pits, in

thatched roofs, roots and mosses and under ferns growing on rocks; also "traditional" farm crops (Ref.). Activity for 2-3 months in June to October (India). Population ~600 m^{-2} around compost pit. Casting is in form of small towers with central openings (Ref.).

Genus ***Octochaetona*** Gates, 1962: 186

Type-species: *Octochaetus surensis* Michaelsen, 1910: 88.

Diagnosis: Small oesophageal gizzard (in 6?) in coelomic space where septa abortive, one pair of calciferous glands opening in or around 15/16, intestinal origin behind 16 with a ventrally bifid typhlosole. Hearts 10-12. Dorsal blood vessel single. Meroic, avesiculate. Setae lumbricine with 17 and 19 penial. Dorsal pores present. Quadriprostatic, pores or tubular prostates at ends of seminal grooves in 17-19. Quadrithecal, pores intrasegmental.

Distribution: India and two species widely transported.

Note: Octochaetids are referred to *Monogaster* if of African origin and *Octochaetoides* (with discrete calciferous glands) and *Octochaetona* (with large calciferous glands) if Indian; in Australia and New Zealand a possibly unrelated genus (Lee, 1959) is *Octochaetus* Beddard, 1893 (syn. *Neodiplotrema* Dyne) that typically lacks penial setae, has its dorsal vessel paired and spermathecal pores intersegmental and which Lee (1959) considered to be closer in relationship with the N.Z. acanthodrilid '*Eodrilus*' (now = *Diplotrema*).

Key to widespread/peregrine species of *Octochaetona*

1. Spermathecal pores mid-ventral in aa lines, unpigmented, metandric ..... *O. beatrix*
   Spermathecal pores in ab lines, pigmented, holandric 2
2. Prostomium open epilobous, last hearts 12, septum 7/8 present .... *O. paliensis* (Stephenson, 1907) (syn. *riparius* Stephenson, 1920; *ganeshae* Stephenson, 1920), widespread in Southern India and similar to *O. phillotti* (Michaelsen, 1907).
   Prostomium closed epilobous, hearts 13, septum 7/8 absent ..... *O. surensis*

Octochaetona beatrix (Beddard, 1902)

Fig. 1.21 *Octochaetona beatrix* from Samford, (a) ventral view (b) prostates and (c)

spermathecae *in situ* (d) prostomium (e) enlargement of spermathecae (f) gizzard (g) calciferous glands. All but (e) are to the same scale.

Octochaetus Beatrix Beddard, 1902: 456 (sic). [Type locality Calcutta. Types none (Gates) or BM 1904:10:5:242 (Julka)].

Octocheatus fermori Michaelsen, 1907: 171. Types NHRS 146; MNHU 7358].

Octocheatus hodgarti Michaelsen, 1907: 172. [Types ZSIC ZEV 2852/7].

Octocheatus pittnyi Michaelsen, 1910: 86. [Types ZSIC ZEV 4174/7].

Octochaetus dasi Stephenson, 1914: 346. [Types ZSIC W34/1].

Octocheatus (Octochaetoides) beatrix : Stephenson, 1923: 376 (syn. *dasi*).

Octocheatus (Octochaetoides) fermori tetracystis Stephenson, 1924: 343. [Types BM].

Octochaetus lunatus Gates, 1929: 24. [From Mandalay. Types USNM 19255 + BM].

Octochaetoides beatrix: Gates, 1961: 57.

Octochaetona beatrix: Gates, 1962: 213; 1972: 308 (syn. *lunatus*, *femori*); Julka, 1988: 271, figs. 324-328 (syn. *femori, hodgarti, pittnyi, dasi, fermori tetracystis, lunatus*).

Distribution: India (endemic?), Pakistan, Bangladesh, Nepal, Myanmar, Vietnam (Thai, 2000), Malaysian Peninsula (Kuala Lumpur), Philippines, Qld (Blakemore, 1994). This is the first record for this species in Australia.

Locality: Samford; Mundubbera: new records for Qld. and Australia.

Habitat: Moist, alluvial soil under plant litter; sandy irrigated orchard (RJB). Loams with low organic matter, lawns and grasslands, besides ditches (Julka, 1988).

Registration No.: Numerous specimens collected RJB.

Behaviour: Moderately active, a yellow sticky fluid is ejected when handled.

Length: 92-110 mm (40-134 Julka).

Width: 4-5 mm (2-5 Julka).

Segments: 129-198 with much secondary annulation in pre-clitellar region after 5.

Colour: Unpigmented or grey-white bodies, dorsal blood vessel and gut contents visible through epidermis; clitellum bright yellow-orange.

Prostomium: Small, closed epilobous: dovetails into wrinkled first segment.

First dorsal pore: Only obvious from penultimate furrow of clitellum 17/18 onwards (Gates, Julka, from 12/13 sometimes 11/12).

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment with ab closely paired cd widely paired but all visible ventrally; ab setae of 17 and 19 penial on small porophores but not

protuberant (ab setae of 18 retained but obscured by folds?), ventral setal couples narrow then diverge conspicuously after clitellum; (ca. 2.0:1.0:2.5:1.3:16.0:0.6).

Nephropores: None visible.

Clitellum: Annular: 13-17,18; setae retained, furrows obscured.

Male pores: Male field a circular hollow from ½17-½19, male pores presumed on 18, in seminal grooves which run vertically from slight prostatic porophores in a lines on 17 and 19.

Female pores: Pair anterio-ventral to aa in lateral depressed groove on 14.

Spermathecal pores: Two pairs mid-segmental, mid-ventral just anterior to aa in 8 and 9 in small co-joined pad-like papillae (irregular black setae observed in these corny pads in one specimen possibly the partners' detached penial setae following amphimixis?).

Genital markings: None.

Septa: 4/5/6 muscular, 6/7 and 7/8 aborted (5/6 also absent Julka), 8/9-11/12 thick and shifted backwards, 12/13-19/20 moderately thick.

Dorsal blood vessel: Single, continuous over gizzard onto long, retracted pharynx in 4-5.

Hearts: 10-13 (in 13 a pair of large vessels branch laterally on side wall of clitellum then divert posteriorly).

Gizzard: Large, muscular and onion shaped but flattened occupying 7 and 8 (in region of aborted septa).

Calciferous glands: Large single pair of convoluted calciferous glands in 15/16 attach ventro-laterally to gut through short ducts.

Intestine origin (caeca, typhlosole): 16 (17 Julka) after calciferous glands; no caeca, large bifid lamelliform typhlosole commence after constriction in about 24,25.

Nephridia: Meroic, numerous micro-tubules in each segment.

Male organs: Testes/funnels testis funnels in 10 and iridescent in 11, the anterior pair smaller; large, smoky seminal vesicle in 12 (i.e metandric but funnels of 10 retained).

Ovaries: (+ Oviducts) paired in 13, palmate each with several egg strings; ovisacs in 14.

Prostates: Two pairs of small convoluted tubular prostates on short ducts and with sheaths of the penial setae close to ectal ends, confined in each of 17 and 19; between the sets of prostates the interior bodywall in 18 has a muscular sheen.

Spermathecae: Two pairs, bulbous ampullae tapering to short, wide ducts bear single, small, sub-spherical to flattened, iridescent diverticula, (diverticula may be enclosed in attached sheaths so care is needed to tease them out). Julka says ventral setae on 8 and 9 also slightly ornamented.

Gut contents: Very fine silt plus coarse sand granules and some unidentified organic matter (geophagous?).

Notes: This species was found in relatively high numbers in sandy, irrigated soil in recently planted rows (therefore not heavily contaminated with pesticides?) of young citrus in the Golden Mile orchard at Mundubbera. At Samford, it was only occasionally found in association with *Aporrectodea trapezoides* and other species under litter in alluvial pasture. Good regeneration after damage was noted but survival in culture was only fair. It is believed to be geophagous. Cocoons are dark red/yellow, lemon shaped about 6 mm long.

Julka (1988) says its populations reached 300m^{-2} in grassland in Orissa, and that it has facultative diapause when conditions are too dry or hot. Reproduction is biparental and copulation and feeding occurs below ground.

Cocoons are roundish and incubation is about 3-4 weeks.

Octochaetona surensis Michaelsen, 1910

Octochaetus surensis Michaelsen, 1910: 88. [Type locality Sur Lake, Puri district, Orissa India. Types none]; Stephenson, 1923: 394, fig. 200 of a spermatheca; Gates, 1972: 309 (syn. *birmanicus*).

Octochaetus surensi (laps.), Stephenson, 1916: 338, fig. 31.

Octochaetus (*Octochaetoides*) *birmanicus* Gates, 1925: 55. [Type locality Rangoon. Types in Indian (e.g. ZSIC W1176/1), British and US National Museums].

Octochaetoides surensis: Gates, 1955:78.

Octochaetona surensis: Gates, 1962: 213; 1972: 309; Julka, 1988: 293 (syn. *birmanicus*).

Distribution: Northwestern India (endemic?) between the Orissa coast and the Jubbulpore section of the Central Provinces through to Tamil Nadu in the South; introduced to Myanmar.

Locality: Not found in current studies.

Habitat: Soil around villages and other settlements, plant pots and botanic gardens.

Registration No.: N/A.

Behaviour: Geophagus.

Length: 60-140 mm.

Width: 2.5-6 mm.

Segments: To 180.

Colour: Brown dense pigment.

Prostomium: With posteriory narrowed tongue.

First dorsal pore: 12/13.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment; setae ab on 8-9 copulatory; 17 and 19 penial. (ab<cd<bc<aa, dd>=0.5U).

Nephropores: ?

Clitellum: 13-16,17.

Male pores: Male field a circular hollow from 16-20, male pores presumed on 18 in seminal furrows in b lines from 17 to 19.

Female pores: On 14.

Spermathecal pores: Two pairs mid-segmental just anterior to ab segmental in 8 and 9.

Genital markings: Tumid areas surround spermathecal and male pore fields; slight epidermal modification in aa, paired or median in some of 18-22.

Septa: 4/5 muscular, 5/6/7/8 aborted, 8/9-10/11 shifted posteriorly.

Dorsal blood vessel: Single.

Hearts: Last pair in 13.

Gizzard: Small in 6?

Calciferous glands: Large single pair of convoluted calciferous glands in 15/16.

Intestine origin (caeca, typhlosole): 17; no caeca; bifid typhlosole after 22,23.

Nephridia: Meroic, numerous micro-tubules in each segment.

Male organs: Testes/funnels in 10 and in 11; seminal vesicle in 9 & 12.

Ovaries: In 13.

Prostates: Two pairs of tubular prostates with penial setae in 17 and 19.

Spermathecae: Two pairs, small, duct barrel-shaped, diverticulum multilocular.

Gut contents: Geophagous.

Notes: Although surviving in dry zones after introduction to Myanmar, this species does better in alluvial soils and is mainly from settled areas (i.e., not in rain forests).

Julka (1988: 296) says that when soil is moist this worm produces surface casts 4-5 cm high and these can ammount to 47tons (sic) of dry worm casts per acre per year. This species is relatively well studied in India and is said to enrich soil (citation).

Genus ***Ramiella*** Stephenson, 1921

Syn. *Ramella* Michaelsen, 1921: 37 (lapsus calami pro *Ramiella* Stephenson, 1921: 109).

Type-species: *Octochaetus bishambari* Stephenson, 1914 from Saharanpur, India.

Diagnosis: Digestive system with single oesophageal gizzard (in 5, 6, or possibly 7), without caeca or calciferous glands; intestinal origin behind 13 (and anterior to 16). Hearts 10-12. Dorsal blood vessel single. Meroic, avesiculate. Setae, lumbricine; penial setae on 17 and 19. Dorsal pores present. Quadriprostatic, pores of tubular prostates at ends of seminal grooves in 17-19. Quadrithecal, pores intersegmental or intrasegmental.

Distribution: India (western part of Gangetic plain south through to Coorg and Chennai), with the range of the type-species extended by transportation. Gates (1972) speculated that *Ramiella* representatives in Burma, e.g. *Ramiella parva* Stephenson, 1924 (possibly synonymous with *R. bishambari* according to Gates, 1972: 313), were peregrine species taken there before the arrival of the Portuguese. The species, *Ramiella americana* Gates, 1957 from Guatamala was later transferred to *Ramiellona*. About half a dozen species are known, most are inadequately characterized, and Central American species are no longer included in this genus (Gates, 1942: 122; 1972: 311).

Ramiella bishambari (Stephenson, 1914)

Octochaetus bishambari Stephenson, 1914: 347. [Non *Eutyphoeus bishambari* Stephenson, 1914: 355 (= *Eut. orientalis*)]. [Type locality, Saharanpur, India. Types, British Museum 1933:5:25:918-9].

Octochaetus pachpaharensis Stephenson, 1920: 239. [Types Calcutta: W258 and BM].

?*Ramiella parva* Stephenson, 1924: 344; Gates, 1972: 313. [From Shan States, Myanmar, probably by human introduction. Types in Indian Museum].

Ramiella cultrifera Stephenson, 1931: 187. [Type locality, Rangoon, Myanmar. Types in British Museum 1930:12:27:66 (lost?)]; Michaelsen, 1935: 103; Gates, 1942: 122.

?*Howascolex sinicus* Chen, 1935: 113, fig. 2; Chen, 1959: 7, fig. 5. [From Amoy, Fukien south China. Known only from holotype that was sectioned (on 9 slides) and deposited in Museum of Biological Laboratory Science Society, Shanghai, China: No. 1015].

Ramiella bishambari: Gates, 1972: 312-313 (syn. *cultrifera*, ?*sinicus*,?*parva*); Julka, 1988: 317, 345 figs. 387-390 (syn. *pachpaharensis, cultrifera, ?sinicus*).

Diagnosis: Octochaetidae with male pores in seminal groove on 18 in ab lines and

prostatic pores with penial setae in 17 and 19. Spermathecal pores in 7/8/9 in setal b lines. Genital markings present or absent. Calciferous glands and intestinal caeca absent.

Distribution: India (south and central), Pakistan, Myanmar, Vietnam, Philippines, Andaman, Christmas Island (Australian territory) south of Java (Gates, 1935); and from Amoy in Fukien Province, China (if, as Gates argues, Chen's *sinicus* is synonymous). The following account is extracted from Stephenson (1923), Julka (1988), Gate's description, from Chen's *H. sinicus*, and from Michaelsen's report of *cultrifera*.

Habitat: Gates reports it from organic soil, effluent ditches and a municipal dump. Julka says it is found in soil with high organic matter and pH 6-8 especially in grasslands, but also in roots of mosses and ferns growing on rocks and under stones on banks of streams.

Behaviour: Reported as quiescent during dry periods.

Length: 20-38 mm (45 *H. sinicus*).

Width: ca 1 mm.

Segments: 82-91.

Colour: Unpigmented.

Prostomium: Open epilobous.

First dorsal pore: In region of 6/7-10/11.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment with closely paired with ab = cd; ab setae of 18 lacking, those of 17 and 19 long and penial in setigerous sacs.

Nephropores: None visible.

Clitellum: Annular or saddle-shaped in 13,14-17.

Male pores: In seminal groove on 18 in ab lines.

Female pores: Pair anterior to setae a on 14.

Spermathecal pores: Two pairs just porterior to intersegments 7/8 and 8/9 in setal b lines; genital setae absent.

Genital markings: Variable in location and number – in or near ab lines presetal in 7-9, 17, 20; postsetal in 7, 8, 10, 11, and 19 or 19/20 (the last unpaired and median); or absent - none described by Stephenson (1923), nor by Chen for *H. sinicus*.

Septa: 5/6-12/13 progressively muscular.

Dorsal blood vessel: Single.

Hearts: 9,10-12 [in *H. sinicus* those stated to be in 13 are actually connectives to the dorsal vessel from the extra-oesophageal vessels according to Gates (1972: 312)].

Gizzard: In 6 (or believed to be in 7 in *R. cultrifera* and *H. sinicus* but the latter description is confused with "*gizzard single, very muscular in 7 (in front of septum 5/6)*"

thus putting it in segment 5, or if "behind septum 5/6" is meant, then in 6).

Calciferous glands: None, (but dorsal pharyngeal bulb in 4-5, e.g. in *H. sinicus* which was also claimed to have a "*very slightly developed calciferous gland, differentiated from ordinary epithelium only by a few glands under the epithelium*" in 16 - but these stuctures not shown in Chen's figure 2).

Intestine origin (caeca, typhlosole): 14, typhlosole rudimentary as low ridge only from 17; (*H. sinicus* was described with 'oesophagus' much wider from posterior part of 13 and the intestine narrower, beginning in about 20 without a typhlosole - but Chen's figures show the intesine commencing in 14).

Nephridia: Meroic in 2-3 ranks on each side per segment, at least in postclitellar segments; (in *H. sinicus* in about the last 20 segments meganephridia were found). Note: Stephenson (1923) said that only a pair of "*meganephridia*" were present but this was perhaps in forebody and was corrected by Gates (1972).

Male organs: Testes/funnels in 10 and 11; seminal vesicles in 11 (always?) and 12; or vesicles increasingly larger pairs in 10-12 in *H. sinicus*.

Ovaries: A pair in 13; ovisacs sometimes in 14.

Prostates: Two pairs of small looped tubular prostates on short ducts in each of 17 and 19; penial setae present; (in *H. sinicus* the prostates are described and figured with the glandular portion "*cylindrical and warty on the surface*" - it is not known whether this is an artefact of preservation, parasitism, or a form transitional to a tubuloracemose gland).

Spermathecae: Two pairs, in 8 and 9; duct longer than ampulla, diverticulum ellipsoidal, sessile at ental end of duct.

Gut contents: ?

Notes: Gates' synonymy of *H. sinicus* in *R. bishambari* appears justified as in a footnote he accounted for all the supposed differences, the only dubious qualifier for *Howascolex* was supposed presence of calciferous lamellae in 16 (or 14?), but Gates (1972: 276) thought this latter genus a taxonomic "*waste basket*" with species supposedly from southern India, Madagascar and America. The prostate glands of *H. sinicus* are interesting as they appear with slight surperfical lobulations but are, nevertheless, described as "*tubular*" by Chen (1935: 119) and figured as thickly tubular coils.

Ramiella parva Stephenson, 1924 is possibly a parthenogenetic morph, found in Myanmar, that lacks both modified penial setae and spermathecal diverticula (Gates, 1972: 313).

Regeneration of both head and tail portions is possible (Gates, Julka).

May be superficially confused with acanthodrilid *Eukerria saltensis* and its ilk.

Family **Megascolecidae** Rosa, 1891

Megascolecidae Rosa, 1891: 379 (part.); Beddard, 1895; Michaelsen, 1900; Stephenson, 1930; Lee, 1959; Gates, 1959, 1972; Blakemore, 2000 – definitions differ.

Type-species and type-genus: *Megascolex caeruleus* Templeton, 1844 from Ceylon.

Diagnosis: Male pores united with prostatic pores, paired or unpaired (eg *Fletcherodrilus* Michaelsen, 1891) commonly on 18, rarely on 19 or 20. Prostates tubular to racemose; nephridia holoic or meroic; setae lumbricine to perichaetine. Dorsal pores present or absent. Oesophageal gizzard(s) present; calciferous glands present or absent; intestinal gizzard(s) and caeca sometimes present, or absent. Spermathecae single, paired, or multiple; diverticulate (or rarely with intramural sperm chambers). Last hearts behind segment 11.

Taxonomic Note: *Pontodrilus*, *Plutellus*, *Argilophilus*, and *Diporochaeta* are returned to Megascolecidae from Acanthodrilidae *s.* Gates while *Megascolides*, *Scolioscolides* and *Celeriella* are now moved to Megascolecidae from Octochaetidae *s.* Gates.

Male pores combined with prosatic pores (on 18) is the family characteristic, but typically not on segment 17 as in some Acanthodrilidae. However, segmental counts may be decreased by one where there is deletion or suppression of the anterior segment in some species and some genera (determined by the ovaries and female pores being displaced anteriorly), e.g. *Tonoscolex* Gates, 1933 and *Nelloscolex* Gates, 1939, both from the Indian region, have female pores on 13 and male pores on 17 (in seminal grooves but apparently combined with pores of tubuloracemose prostates). Furthermore, prostates and spermathecae are degraded or aborted in some parthenogenetic morphs, in which case it is necessary to seek more completely developed representatives of the taxon.

Distribution and diversity: Australasia; India; Asia and Oceania; (possibly including Antarctica in past geological times); North and Central America. In North America megascolecids (Argilophil-inae/-idae) mostly occur in a narrow coastal forest strip from Alaska to central California but are found further east in Washington and Oregon reaching into Idaho. A large family with in excess of 2,000 named taxa; many species are peregrine, particularly some of the 940 valid Oriental pheretimoids (from a total of about 1,400 nominal taxa), and the remainder of the family comprises an additional 1,000+ species names. [Most current datasets (Csuzdi, 2003; Blakemore, 2005; 2006/7) have many omissions plus *spp incertae sedis* or *spp inquirendae* requiring resolution from type inspection; but there are countless as yet undescribed taxa too].

Remarks: Megascolecidae *s. str.* remains the largest of megadrile groupings. It has been re-shuffled into various super- and sub-ordinate ranks in various combinations by disparate authors at different times. It is theoretically possible to identify transitional, intermediate, or adaptive states between holoic and meroic, but the precise nephridial states are often unrecorded and are unlikely ever to be determined for all species. However, practical sub-divisions are possible under the present system of classification with genera having combinations of the 'primitive' states of tubular prostates, holoic nephridia, and lumbricine setae being phylogenetically the most ancestral cf. any other non-primitive states (see sub-family refinement in Appendix). The current revision of families places Australasian genera such as *Plutellus* Perrier, and *Sebbius* Blakemore, 2004b (nom. nov. pro *Sebastianus* Blakemore, 1997 preocc. by a coleopteran) and the North American and Indian *Argilophilus* Eisen, 1893 (see Eisen, 1894), as rather primitive members of the Megascolecidae, while *Diporochaeta* and *Perionychella* are slightly more derived members of Megascolecidae, and Indian *Megascolex*, Australasian *Anisochaeta* or Oriental pheretimoids the most developed.

Relatively 'primitive' North American genera previously placed in *Plutellus* and *Megascolides* have now been put in nine genera [viz. *Arctiostrotus, Argilophilus, Chetcodrilus, Drilochaera, Driloleirus* (the only meroic genus), *Kincaidodrilus, Macnabodrilus, Nephrallaxis*, and *Toutellus*] under an as yet poorly defined tribe Argilophilini Fender & McKey-Fender, 1990 that is found in the Pacific Northwest (Fender & MacKey-Fender, 1990: 357-378; Fender, 1995: 54) (including India for *Argilophilus* and Australia if *Graliophilus* is included in synonymy). Validity and taxonomic level of the tribe Argilophilini within the Megascolecidae s. stricto are indeterminable on the data available (cf. Plutellidae/Pontodrilidae). A report of *Argilophilus marmoratus* Eisen, 1893, the type-species of the genus, from northern NSW, Australia by Jamieson (1977) failed to state which sub-species was claimed although, eitherway, it appears unverified as it is not mentioned in Jamieson (2000) – see also the false Australian reports of *Metaphire javanica* and of *Lumbricus terrestris*.

'Advanced" megascolecid genera are Indian *Megascolex* Templeton, 1844 s. str (syn. *Perichaeta*) and *Lampito* Kinberg, 1867 s. str.; Australian/NZ *Anisochaeta* Beddard 1890 (syn. *Propheretima*); and Oriental pheretimoids e.g. *Amynthas* Kinberg, 1867, *Metaphire* and *Pheretima* s. stricto (see Sims & Easton, 1972; Easton, 1979).

Many classical species names were transferred to *Pheretima* s. lato from the genus *Perichaeta* Schmarda, 1861 [type-species *Pe. leucocyla* Schmarda, 1861;

synonyms *Perichoeta*: Vaillant, 1867 (laps.); *Pericheta*: Perrier, 1874 (laps.)] which has long been combined as a junior synonym of the Sri Lankan genus *Megascolex* Templeton, 1844 for reasons explained by Horst (1883: 182), Michaelsen (1900) and Sims & Easton (1972: 175) [Cf. Sabrosky, 1999 for Dipteran homonyms]. The pheretimoid genera: *Nitocris* Kinberg, 1867 and *Rhodopis* Kinberg, 1867 were preoccupied (see Michaelsen, 1900: 234; Sims & Easton, 1972: 176).

Anisochaeta now accommodates Australasian species formerly placeable in the southern Indian genus *Megascolex* (see Blakemore, 1997b; 2000a; 2000e; 2006). Indian species of *Megascolides* were transferred to *Scolioscolides*, *Barogaster* and *Travoscolides* by Gates (1940). North American species of *Megascolides* were transferred to holoic *Arctiostrotus* by McKey-Fender and Fender (1982) [e.g. *Arctiostrotus perrieri* (Benham, 1892) from Queen Charlotte Island, Canada and Oregon, USA] and to the meroic genus *Driloleirus* by Fender and McKey-Fender (1990). *Celeriella* Gates, 1958 is primarily an Indian genus that provisionally receives the residue of species from Australia and New Zealand with tubular prostates that were formerly part of *Spenceriella* Michaelsen, 1907, after removal of the type-species of the latter genus to *Anisochaeta* (see Blakemore, 2000a; Lee et al., 2002). [Blakemore (2000e: 458) suspected that this synonymization of *Spenceriella* following supposed discovery of non-tubular prostates in the type-species, *Diporochaeta notabilis* Spencer, 1900 (see Blakemore, 1997b: 1823) may be incorrect, as recent evidence suggests the prostates are in fact tubular and should this be proven in the type then the genus would require restoration with some original members].

About 25 exotic megascolecids are currently recorded from Australia including members of the New Guinean genus *Begemius* Easton, 1982 that are 'neoendemics' in north-eastern Australia (Blakemore, 1999). Initial mode of introduction may be similar to those mentioned above for the exotic Acanthodrilidae.

The Australian genus *Anisochaeta* Beddard, 1890 has some members transported (see earlier section on '**Translocation and export of natives and early import of exotics to Australia**' - here), both within the country and overseas; this genus is similar to Indian genera *Megascolex* Templeton, 1844 s. strict. and *Lampito* Kinberg, 1867 s. strict. (see Introduction above). Unlike the pheretimoids, species of these latter genera may have clitella extending beyond segments 14-16; often have wider ventral and dorsal gaps in the setal rings; their gizzards, if present, are before 7/8; and, moreover, they typically lack intestinal caeca (cf. genus *Pheretima* s. lat. below).

Preliminary Key to Peregrine Megascolecidae (i.e. with male & prostatic pores combined on, or near, segment 18; cf. Acanthodrilidae etc. having them separate)

1. Prostates tubular; setae 8 per segment (i.e, lumbricine); holoic but nephridia absent from anterior segments; littoral (cf. Criodrilidae) ……..… *Pontodrilus*

   Prostates non-tubular (tubuloracemose to racemose) …… 2

2. Holoic (i.e., one pair of nephridial tubules per segment) …… *Perionyx* [1]

   Meroic (more than one pair of tubules, at least in some part of the body) …. 3

3. Setae 8 (i.e., lumbricine) ……. *Notoscolex/Nellogaster/Lennoscolex* [2]

   Setae >8 (i.e., anisochaetine to perichaetine) ……..…… 4

4. Gizzard(s) before 7/8 ……..…… *Megascolex*/*Anisochaeta*/*Lampito* s. str. [3]

   Gizzard(s) behind 7/8 ……..……..……..…….. *Pheretima* s. lat.[4]

[See proposed sub-families refinement in Appendix – here].

[1] *Perionyx* Perrier, 1872 is similar to the Australasian *Perionychella* Michaelsen, 1907 (syn. *Terrisswalkerius*); separation is on the degree of development in segment 5-6 of the gizzard which is weak, vestigial or lacking in *Perionyx*. The Australian genus *Woodwardiella* Stephenson, 1925 differs by being lumbricine.

[2] Lumbricine species that are shown to be meroic, with non-tubular prostates are distributed in these genera: *Notoscolex* Fletcher, 1886 with its base in Australia/New Zealand, and its probable junior synonyms, *Nellogaster* Gates, 1938 based on its Sri Lankan type-species *Nellogaster bahli* (Stephenson, 1925) and *Lennoscolex* Gates, 1960 presumed endemic to south India with both its species: *Lennoscolex pumila* (Stephenson, 1931) and *Lennoscolex javanica* (Michaelsen, 1910) also found in Myanmar and Java, probably after accidental introduction (Gates, 1972: 136). These are described briefly below. Similar genera are *Tonoscolex* Gates, 1933 and *Nelloscolex* Gates, 1939 that differ by having female and male pores on 13 and 17, rather than the more usual 14 and 18. These two genera should perhaps be combined but, of the species included in *Tonoscolex* by Gates, *ferinus* Gates, 1933 and *horai* Stephenson, 1922, are perichaetine and thus require transfer or return to *Megascolex*. The American (and Indian) genus *Argilophilus* Eisen, 1893 (see Eisen, 1894) also keys out here, one enigmatic species, *Argilophilus hyalinus* Eisen, 1900: 163 is reported from Coban, Guatemala - known only from the description of a single, macerated specimen.

[3] *Lampito* s. str. is restricted to meroic, perichaetine species with bidiverticulate spermathecae and a gizzard in segment 5. Similar genera are *Megascolex* Templeton, 1844 s. str. in the Sri Lankan/Indian region as discussed by Stephenson (1923: 222) and *Anisochaeta* Beddard, 1890 in the Australasian region - these two genera are separated following Blakemore (1997b: 1822; 2000a; 2000e) as mooted by Gates (1972: 132). *Anisochaeta* now accommodates most of the Australian and New Zealand natives that were formerly placed in the genera *Megascolex*, *Perichaeta*, *Trichaeta* and *Spenceriella*. Widely distributed *Anisochaeta* are reported above, and *Megascolex filiciseta* Stephenson, 1915: 94 from India that occurs in Parambikulam (Kerala) and natural forest in Westen Ghats (Tamil Nadu), India is reported as an (introduced) anecic in fields in North Lampung (Sumatra) by Wibowo (1999) cited in Hairiah (1999) as tabulated in vanNoordwijk *et al*. (2004). *Anisochaeta macleayi* is described here and below.

[4] Peregrine *Pheretima* s. lat., or the "pheretimoids", are keyed out separately (jump to key).

[**Note:** Megascolecidae genera are herein arranged in approximate phylogenetic order, rather than alphabetically, predicting future familiar division as appended – here].

Genus ***Pontodrilus*** Perrier, 1874

Pontodrilus Perrier, 1874: 1528; Michaelsen, 1900: 179.

Type-species: *Lumbricus litoralis* Grube, 1855 - originally found on Mediterranean coast at Villafranca (Villefranche-sur-Mer), and later at Nizza (Nice), Marseilles, and Cannes, in southern France.

Diagnosis: Setae lumbricine (i.e., eight per segment). Dorsal pores absent. Female pores paired on 14. Male pores paired on 18 combined with pores of tubular prostates. Gizzard rudimentary in 5 or absent; extramural calciferous glands absent; typhlosole absent. Nephridia avesiculate holoic, lacking in pre-clitellar segments. Spermathecae two-four pairs with clavate or multiloculate diverticula. Penial setae absent or present.

Distribution: One species (*P. litoralis*) circummundane – on shorelines in the tropics and warmer parts of continents and islands in all the world's oceans; one species (*P. primoris*) littoral in Tasmania; another species lacustrine in NZ; others terrestrial in Sri Lanka and China [see distribution map].

Regarding the genus *Pontodrilus* it was said by Gates (1972: 47, 48) that: "*Nothing is known as the original home of the species (one guess, in the region of Australia-New Zealand) or as to how species have spread around the world....The agent involved in this instance seems unliekly to have been man...Absence of geographic variation does suggest that transportation may have been recent*".

Bouché *et al.* (2004: 382) argue thus: "*Today the Pontodrilus occupy the area of the primitive Tethys Sea and freshwater environments in Australia. This genus adapted to the marine environment simultaneously with the marine monocotyledons [SEAGRASSES] (Posidonia, Zanicheliedacea) and remains today dispersed in the Indian Ocean, Oman Sea, Mediterranean, and West Indies with diversifications into multiple species among which Pontodrilus litoralis is a Mediterranean <<species>> not yet mentioned from North Africa where its presence may be predicted*." [But actually already recorded from Djerba Island off Tunisia by Michaelsen (1925/6) as reported by Omodeo *et al*. (2003: 2)]. Report of pet cockatoos in Sicily in 13th C (Ref.) indicates early Oceanian trade. Moreover, *P. litoralis* has no similarity with French natives, rather it resembles Indo-Australasian megascolecids (plutelloids) with the development of tubular prostate glands and a gizzard in or near segement 5.

Taxonomic Remarks:

(Sub-)Family placement

Pontodrilus belongs to the family Megascolecidae rather than Acanthodrilidae where it had been placed by some earlier authors. It is newly resolved (Ref.) into a sub-family **Pontodrilinae** Vejdovsky, 1884 with tubular prostates (and holoic nephridia), as also found in tribe Argilophilini, [type American *Argilophilus marmoratus ornatus* Eisen, 1893 – see Eisen, 1894) proposed (including meroic *Driloleirus* that probably requires relocation) by Fender & McKey-Fender (1990) - although this name competed for priority with Vejdovsky's (1884: 63) Pontodrilidae and Plutellidae (types Indo-australasian *Pontodrilus litoralis* Perrier, 1874 and Australian *Plutellus heteroporus* Perrier, 1873), respectively]. The residue of megascolecid species comply with sub-family Megascolecinae having derived non-tubular prostates (as for the Indian type *Megascolex caeruleus* Templeton, 1844). Further, secondary and subordinate division may be 'convenient' within these two sub-families on basis of such features as holoic vs. non-holoic nephridia or lumbricine vs. non-lumbricine setae. Due possibly to the "*well known dependence of the conformation of the alimentary tract on food and environment*" (Stephenson, 1930: 720), the position within Octochaetidae [type N.Z. *Octochaetus multiporus* (Beddard, 1885)] of sub-family Benhamiinae, currently defined by its arrangement of calciferous glands, is not fully resolved; and neither is the status, validity nor extent of the polygiceriate Diplocardiinae sub-family of Acanthodrilidae (type New Caledonian *Acanthodrilus ungulatus* Perrier, 1872).

Generic placement

The genus *Pontodrilus* is characterized by holoic nephridia absent from anterior segments, and tubular prostates ducting to male pores on segment 18 (cf. 13 or 15 in Criodrilidae) and was reviewed by Michaelsen (1900), Stephenson (1930), Lee (1959), Easton (1984), and Blakemore (2000; 2002; 2006). Its nearest relatives may be found in plutelloid genera such as *Plutellus* Perrier, 1873, now confined to Australia's central coastal NSW, and *Argilophilus* Eisen, 1893, know from both India and northwestern North America (Blakemore, 1994; 2000; 2006), plus enigmatic *Argilophilus hyalinus* Eisen, 1900 from Coban, Guatemala - known only from the description of a single, macerated specimen [*Latin hyalinus*, from hyalinos (Gr) "of glass", often referring to the transparency of the body] that is probably misidentified.

Lee (1959) recognized five species, these were: the littoral *Pontodrilus*

litoralis Grube,1855, *Po. bermudensis* Beddard, 1891, and *Po. matsushimensis* Iizuka, 1898, as well as lacustrine *Po. lacustris* (Benham, 1903) free-swimming in Lake Wakatipu (or Wakitipu) near Queenstown, New Zealand at depths of 100-400 m, and terrestrial *P. agnesae* Stephenson, 1915 from Horton Plains near Adam's Peak and Elk Plains, Sri Lanka. Easton (1984) revised the species, placing all three littoral species in synonymy of *Po. litoralis* and remarking that the other species - plus *Po. sinensis* Chen & Zhifang, 1977: 23 that is diagnosed below – are sometimes (erroneously) placed in the allied genus *Plutellus* by some authors. Although the non-littoral species may be transferable to new genera, none would comply with *Plutellus* following revision of this genus (see Blakemore, 1994). Easton (1984) stated:

> "Pontodrilus lacustris*, which has been recorded from lacustrine habitats, may be distinguished from* P. litoralis *by having 4 pairs of spermathecae and penial setae;* P. agnesae*, from terrestrial habitats, can be distinguished by the presence of penial setae.* P. sinensis *is either terrestrial or lacustrine - the original description lacks detail but the type locality is 250 km from the coast - and can be distinguished from* P. litoralis *by possessing seta b (? and a) on 18 and four pairs of seminal vesicles in 9-12. The relationship between the 4 species of* Pontodrilus *are unknown*."

Stephenson (1923: 182) does not mention penial setae for *P. agnesae* although he notes that the prostomium is prolobous and last hearts are in 12 in this species that lives in the Horton and Elk Plains of Sri Lanka.

Diagnosis of *Pontodrilus sinensis* Chen & Zhifang, 1977: 23: L.30.5-41.0 mm., D.1.2-1.8 mm., segs.67-94 (type:36.5mm.,1.5 mm.,segs.93). No dorsal pores. Clitellum saddle-shaped 13-18,1/2-2/318. Setae 4 pairs per segment, aa=2.5-3ab,bc=cd=2ab,aabc,dd:<1/2 of body circumference.

Origins

The origin of *Pontodrilus* is undetermined although Gates (1972: 47) and Blakemore (2000e) argued it to be in the region of Australia or New Zealand. Three distinct species are known from these two countries, one is lacustrine, the other two littoral with the cosmopolitan *P. litoralis* shared with many other parts of the world including Australia. Recently a second littoral species was described as *Pontodrilus primoris* Blakemore, 2000 - the first record of an endemic *Pontrodrilus* from Tasmania, that is characterized by: genital markings widely paired in 18/19 and 19/20 in ab lines, and sessile, bifid or multiloculate spermathecal diverticula. Having a second littoral species puts Australia, with its huge and often tropical coastline, in contention for the

provenance of the genus.

Blakemore (2007b) proposed that it may be endemic to both Australia and India, presumably evolving to its beach habitat before separation of east Gondwana earlier than about 120 million years ago.

Little is known of the life-history nor means of distribution of the species. It is probable that these beach-living worms have been widely transported with cargo ships' sand-ballast, as Lee (1987: 315) supposes for some other species. The cocoons are known to be attached to floating twigs and similar debris (Subba Rao & Ganapati, 1974) so it may be speculated that the cocoons of *P. litoralis*, like other life stages, are euryhaline and are readily dispersed by ocean currents (Stephenson, 1923: 25; 1930: 662; Lee, 1969: 351; Lee, 1985: 66; Sims, 1980: 117) or, more recently, taken up with ships' water-ballast. Sims (1980: 117) remarks on the similarity of distribution around tropical and sub-tropical beaches of *Pontodrilus* and of *Pontoscolex corethrurus*, he suggests the dispersal mechanism as: "*both seemingly are rafted around the tropics*".

Ships have carried beach sand ballast for thousands of years (e.g. Stevens, 1871; Harland, 1984: 94) and since the late 20th Century seawater ballast has been used; thus the distribution and lack of diversity of *Pontodrilus litoralis* may be attributed to its primary transportation in sand (or more recently in water) ballast with secondary dispersion via rafting on floating debris, this dependant upon the cocoons surviving immersion. Stephenson (1923: 182) describes specimens on the Malabar Coast found "*in a rotten palm-tree lying in the water*", so possibly rafting logs are another dispersal mechanism for this worm.

Easton's synonymy of diverse forms under *P. litoralis* suggests that either there is frequent global recruitment of this species, or that despite being highly variable intraspecifically it has remarkably conservative morphology, or, possibly, that this synonymy is too broad. Gates (1972: 48) stated that "*Absence of geographic variation does suggest that transportation may have been recent*", although a converse view, especially when *Pontodrilus* is more correctly placed in Megascolecidae, is of rather primitive species that may have precursors close to the original forms of this family, living in a fairly constant littoral habitat. Stephenson (1930: 834) said he "*formerly thought that [Sri Lankan] P. agnesae might represent the terrestrial ancestor from which the littoral species have descended (Stephenson, '23) but ... the opposite may be the case, and the terrestrial and limnic species of the genus may owe their origin to the survival and modification in a new environment of*

colonies accidentally transported from the shore". Extension of these ideas raises interesting possibilities for the origins of the family Megascolecidae, especially as these relate to zoogeography and the separation of the continents through geological time.

Other littoral species include *Microscolex macquariensis* in family Acanthodrilidae that was found in similar litoral habitats under beach pebbles on Macquarie Island by the current author; also *Pontoscolex arenicola* Schmarda, 1861 (cf. *Pontoscolex corethrurus*), *Diachaeta thomasi* Benham, 1886 and *D. littoralis* Beddard, 1892 from the Caribbean, plus certain species of *Microscolex* and *Dichogaster*.

Pontodrilus litoralis (Grube, 1855)

Fig. 2.1 *Pontodrilus litoralis*, NSW specimen, ventral view showing: A, dorsal view of prostomium, B spermathecae and C, prostate *in situ*; with D, a cocoon (after Subba Rao & Ganapati, 1974: fig. b). The clitellum is shaded, setae and segments are marked, setal ratio on 12 is show and G.M. – Genital Markings.
Fig. 2.1a. *Pontodrilus litoralis* cocoons (after Subba Rao & Ganapati, 1974: figs. a-b).
Photo 1.1, Photo 1.2, Photo 1.3of specimens from Uraga, Miura Peninsula, Japan (2006).

Map 1 original locations of *P. litoralis*; Map 2 new records for *P. litoralis* from current studies; Map 3 world distribution *P. litoralis* (and other *Pontodrilus* species in blue).

Lumbricus litoralis Grube, 1855: 127 (et *littoralis* Grube, 1855 nec Dalyell, 1853). [Type locality Villa Franca (= Villefranche-sur-Mer) at Cote d'Azur on the French Riviera. Syntype in Zoological Museum, Berlin: 216 - dried out according to Hartwich & Kilias (1989: 270); Reynolds & Cook (1989: 30) cite a "*paratypus*" in Wroclaw Univeristy Museum, Poland: 506].

[Note: ICZN (1999: Art 58) states that variant spellings for different nominal taxa, such as use of single or double consonant (e.g. *litoralis, littoralis*), are deemed to be identical].

Pontoscolex arenicola Schmarda, 1861: 11 (part.). [From beaches at Kingston and Port Royal, Jamaica. Types in Vienna Museum]. [Note: Schmarda (1861) confused two species under the same name without giving a type specimen although his figure (fig. 157) was the same as the specimen that Beddard (1892: 126, figs. 3, 6) separated as *Pontoscolex arenicola* (= *Pontoscolex corethrurus*), the other he named *Diachaeta littoralis* Beddard, 1892 (= *Diachaeta thomasi*

Benham, 1886)].

Pontodrilus marionis Perrier, 1874: 1582; Perrier, 1881: 40, 176, fig. 40-43. [From Marseilles, South of France. Types?].

Pontodrilus bermudensis Beddard, 1891: 96 (non *Perichaeta bermudensis* Beddard, 1892a: 160). [From Bermuda. Types none]; Michaelsen, 1894: 183; Beddard, 1895a: 469 (syn. *arenae*, *arenicola* (part)); Michaelsen, 1910c: 84 (syn. *arenicola* (?part), *arenae*, *insularis*, *hesperidum*, *michaelseni*, *m. hortensis*, *ephippiger*, *e. laysanianus*, *laccadivensis*, *P.* sp. Michaelsen, 1894); Michaelsen, 1909 (syn. *insularis, laccadivensis*); Stephenson, 1923: 180 (syn. *laccadivensis*, *ephippiger, arenae, insularis, michaelseni*, *hesperidum*); Chen, 1938: 379 (syn. *matsushimensis* misspelt "matsuchimensis"); Gates, 1943: 99; 1972: 47; 1975: 7; 1982: 33.

Cryptodrilus insularis Rosa, 1891: 387, fig. 11 (of left prostate). [From Aru Island S.W. of West Papua (New Guinea), and later from Sri Lanka. Type (immature and already in poor condition when first described) in Vienna]. [Non Spencer, 1895 (= *Vesiculodrilus insularis* comb. nov. in Blakemore, 2000: 127). This senior homonym was omitted by Reynolds & Cook (1976)].

Pontodrilus arenae Michaelsen, 1892: 222, fig.9 (of a scalloped seta). [From Isla Desterro, Brazil where Müller lived. Types in Humboldt Museum, Berlin: 1512. Name from *Lumbricus arenae* Fritz Müller "*in litteris*" according to Michaelsen, 1892; 1900]; Michaelsen, 1900: 181 [?syns. *arenicola* (part) Schmarda, 1861, *bermudensis* Beddard, 1891]; Moore, 1902: 82.

Pontodrilus sp. Michaelsen, 1894: 184. [From Hillsborough, Ozona, Florida].

Pontodrilus hesperidum Beddard, 1894: 37. [From Jamaica. Types?]; Beddard, 1895a: 471; Michaelsen, 1900: 182.

Pontodrilus insularis: Beddard, 1895a: 471 (syn. *marionis*); Michaelsen, 1900: 181.

Pontodrilus michaelseni Eisen, 1895: 73. [From Guaymas on the Pacific coast of Mexico. Types?]; Michaelsen, 1900: 182.

Pontodrilus ephippiger Rosa, 1898: 277, 281. [From Christmas Island south of Java. Types BM 1898:10:28:24-36]; Michaelsen, 1900: 180 (syn. *arenae, insularis, michaelseni, hesperidum*); Stephenson, 1914: 256.

Pontodrilus matsushimensis Iizuka, 1898: 21, pl. II (segments miscounted). [From Matsushima-wan, Miyagi-ken, Japan (and Kunie or Fichten Island, New Caledonia by Michaelsen, 1900: 180). Types?]; Michaelsen, 1900: 179;

Michaelsen, 1910c:91 (syn. *m. chathamianus*); Easton, 1981: 45.

Pontodrilus ephippiger laysanianus Michaelsen, 1899: 217. [Laysan Archipelago, Hawaii (and later Celebes, and Loreto Baja California by Michaelsen, 1900: 181). Types missing]; Michaelsen, 1900:181 (?syn. *michaelseni hortensis*).

Pontodrilus matsushimensis chathamianus Michaelsen, 1899: 220. [From Te One, Chatham Island, N.Z. Types reported lost from Hamburg Museum but with specimens in Otago Museum, Dunedin]; Michaelsen, 1900: 180 (*P. matsushimensis* var. *chathamiana* (laps.)); Benham, 1901: 129 (*P. chathamensis* (laps.)); Lee, 1952 (*P. matsushimensis* var. *chathamensis* (laps.)); Lee, 1959: 338.

Pontodrilus michaelseni hortensis Eisen, 1900: 129, 241, figs. [From "*garden soil, along sewers in the gardens of Loreto*", Baja California, Mexico. Types?].

Pontodrilus laccadivensis Beddard, 1903: 374. [From Laccadive and Maldive Islands. Indian Ocean. Types?]. [Omitted by Reynolds & Cook (1976)].

Pontodrilus crosslandi Beddard, 1906: 561. [From Sudan, types BM1924:3:1:247-8].

Pontodrilus albanyensis Michaelsen, 1907a:185. [From Albany, WA, Australia. Types Humboldt Museum, Berlin: 7107]; Jackson, 1931: 94.

Pontodrilus bermudensis ephippiger: Stephenson, 1915: 145; Jackson, 1931: 95.

Plutellus (*Pontodrilus*) *bermudensis* : Michaelsen, 1922: 22; 1935: 106.

Pontodrilus albanyensis var. *cygni* Jackson, 1931: 94. [From Swan R., WA. Types?].

Plutellus (*Pontodrilus*) *matsushimensis indica* Michaelsen, 1935: 106. [Types BM 1934:3:12:22]. (Non *Plutellus indicus* Michaelsen, 1907: 148).

Pontodrilus gracilis Gates, 1943: 100. [Florida, Lee Co., Fort Myers, edge of Caloosahatchie River. Types missing]; 1954: 241; Gates, 1982: 35.

Pontodrilus litoralis: Beddard, 1895a: 469 (syn. *marionis*); Michaelsen, 1900:180 (syn. *marionis*); Cognetti, 1901: 404; Michaelsen, 1910c: 89 (syn. *marionis*, *crosslandi*, *albanyensis*); Easton, 1984: 114, fig. 1f [syn. *arenicola* (part.), *marionis*, *bermudensis*, *insularis*, *arenae*, *hesperidum, michaelseni, ephippiger, bermudensis ephippiger*: Stephenson, 1915, *matsushimensis, ephippiger laysanianus* (syn. *michaelseni hortensis*), *matsushimensis chathamianus, michaelseni hortensis, P.* sp. Michaelsen, 1894, *P.*(*P.*) sp. Michaelsen, 1930, *laccadivensis, crosslandi, albanyensis, P.* sp. Michaelsen, 1913, *albanyensis cygni*, *matsushimensis indica*, *P.* sp. Gates, 1936, *gracilis*); Blakemore, 2007: 3 (synonyms as above and full distributions provided in extensive review).

Taxonomic Note: Name sometimes misspelt "*littoralis*" also the name should not be confused with the euryhaline naidid *Paranais litoralis* (Müller, 1784).

Molecular studies: Siddall *et al.* (2001) in a first report on molecular comparison of Annelida, included "*Pontodrilus litoralis* (*bermudensis*)" (sic), see - http://research.amnh.org/~siddall/pub/livanow.pdf ; and also by Staton (2003) and Blakemore (2013).

Distribution: Coasts of Atlantic, Pacific and Indian Oceans, from the Mediterranean, Oman, South China, and Red Seas. Easton (1984: 115) gives these locations:

Atlantic and Caribbean: Bermuda, British Caymans ("*Pontodrilus littoralis* were found in 1985 at Furtherland Farm in George Town and at the southern end of South Sound swamp where they were likely to have been introduced living in soil attached to imported garden plants and vegetables from the USA" - Anon. from JNCC website http://www.jncc.gov.uk/pdf/OT_Cayman.pdf); Virginia, Florida (Hillsborough, Ozona - Michaelsen, 1894: 183), Florida Keys (Siddall *et al*., 2001), Dry Tortugas National Park, Mississippi, Louisiana, Texas, Bahamas, Virgin Is., Haiti, Mona, Is. Jamaica, Colombia, Venezuela, Brazil [e.g. Michaelsen (1910) and from mangroves on Cananeia Island 50 Km southwest of Sao Paulo, Brazil (Righi, 1968)], Moreira, Spain (e.g. Diaz & Moreno, 1981), Canary Is., Cape Verde Is. off the West Coast of Africa, Guinea-Bissau, Angola, tidal flat fauna of the Banc d'Arguin in Mauritania, Congo. A dubious report from Iceland by Delgado *et al*., (2003: Hydrobiologia 496, 311-319), what they call "*Pontodrilus littoralis* Acanthodrilidae" (sic) is likely a mistake, but may be possible if the beach or seawater is heated geothermally. **Mediterranean:** France, Monaco, Sardinia, Djerba Island off Tunisia (Michaelsen, 1925/6 as listed by Omodeo *et al.*, 2003: 2), Andalucia & Almeria, Spain [www.indalodeoz.com/; www.mapa.es/rmarinas/jornada_rrmm/gata_diegomoreno.pdf] and Aegean coast of Greece in Ref. (2015). **Red Sea:** Sudan (Beddard, 1906). **Indian Ocean:** South Africa e.g. Kosi Bay, Zululand by Michaelsen (1913), Tanzania, N.E. Madagascar, Mauritius, Kuwait, Laccadives and Maldives, India [e.g. Chilka Lake, Orissa in damp mud under stones a lake's edge, in wet sand or sand mixed with mud both in the main area and in the outer channel of the lake, the water being either fresh, brackish, or as salty as that of the Bay of Bengal into which it opens - Stephenson (1923: 182), Goa, Madras, Malabar Coast, Travancore, Bombay], Pannikkar, Sri Lanka, Myanmar (Burma), Andaman Is., Nicobar Is., Christmas Is., Java, West Australia. **Pacific Ocean and South China Sea:** Japan [Honshu, Kyushu and, recently (Ref.) Okinawa],

Hainan, Hong Kong (Easton, 1984: 115), Taiwan [by Blakemore, 2004, Blakemore, *et. al.*, 2005, James *et al.*, 2005 (initially as *P. matsushimensis*) and, lastly, by Shen *et al.*, 2005], Vietnam, Borneo (Michaelsen, 1928: 10), Celebes, West Papua (Merauke in wormeaten palm/cycad - Cognetti, 1913: 289) and New Guinea (Gates, 1975), Aru Is., eastern Australia, Caroline Is., New Caledonia (Beddard, 1899), Chatham Is., Tonga, Line Is. (Fanning Island) in the Republic of Kiribati, Hawaiian Is. (including unihabited Nature Reserve Palmyra Atoll 1,600 Km south of Hawaii and Laysan Atoll in the NW Hawaiian group from whence Michaelsen, 1899 described specimens collected by Schauinsland in 1896-1897), Gates (1982: 33) has Chipperton Island, Guam, Palymyra Atoll, Laysan and Fannin Island; also from California, Mexico (e.g. Guaymas, Loreto Baja-California, and salt marsh beach estuary of Oaxaca Bay). A BOLD systems report (Ref.) has *P. litoralis* from Thailand (e.g. Ref.).

For **Australia**: Stephenson (1931) reported *Pontodrilus litoralis* (as *P. bermudensis* Beddard, 1891) from the Low Isles located northeast of Port Douglas, Northern Queensland, in the lagoon area of the Great Barrier Reef. From W.A., Jackson (1931) reported it (as varieties of *P. albanyensis* Michaelsen, 1907 and *P. bermudensis*) from Albany on the shore of Princess Royal Harbour (first settled by Europeans after the Brig *Amity* sailed from Sydney on November 9th, arriving Christmas Day 1826), from Nornalup Inlet, and from from the banks of the Swan River at Claremont (Freshwater Bay, Perth first settled by Europeans 1830). Easton (1984: 115) had many further records, e.g. from Moa Island, Torres Strait, Shark Island in Port Jackson (Sydney Harbour), and Botany Bay (the location of first British and French settlements in 1788), Audley Weir on Hacking River, to Five Islands off Port Kembla, NSW. Specimens in the South Australian Museum were collected from Reevesby Island in the Sir Joseph Banks Group, SA (J. Buckerfield, pers. com. and Ref. 1995). *Pontodrilus* is recorded present in Darwin Harbour, NT (Ref., 1997). This species is also known from Australian territory of Christmas Island south of Java, reported as *P. bermudensis* and as a variety of *P. matushimensis*, by Michaelsen (1935b), (see also Blakemore, 1999).

[Recent reports from landlocked Coimbatore District of Tamil Nadu South India are dismissed as probable misidentifications as they are unauthored].

Locality: The following account is based on the author's descriptions of *P. litoralis* specimens from Apple Tree Bay and Botany Bay, NSW; samples also identified as **New Records:** Galapagos Islands of Santa Rose, San Cruz and San Cristobal,

(numerous specimens collected by M. Mantilla and M. Nakamura, 4-8.VII.1994 identified by RJB); and from the southern beach at Jogashima, Miura Peninsula near Yokohama collected by author and Mr. H. Sakai in 2002 and 2003 and at Uraga with Yuko Hiramoto in July, 2006 (these published by Blakemore, 2007b). Cook Islands (Dec. 2002) also tentatively identified by author (April, 2004) from specimen photos by Dr J-H Chen of NTU from mangroves on north west coast of Taiwan in 2004 as a **New Record** by RJB. Identified in NIBR collection from sand pockets of rocky beach at Odo Island east coast of Jeju-do, Korea also as a **New Record** and this confirmed from specimens at Seogwipo port, Jeju (pers. obs. May, 2012 – published with COI barcode confirmation in Blakemore, 2013: 39). Recently found as **New Record** at Lake Taal in Philippines, collected by the RJB on 10th Nov., 2013 and in Jan. 2014. The latter is interesting because the lake was originally coastal but vocanic activity isolated it and it is now freshwater not saline; possibly the worm has adapted following earlier introduction by the Spanish, unfortunately due to delays its DNA was not extractable to test lineages. [Note: a previous report by me as especially dense at Hinoba-an, Negros Occidental claimed by Flores, 2007 - Ref1. Ref2. was my mistake for his "*Pontoscolex*" not *Pontodrilus*, i.e., *Pontodrilus* not previously reported from Philippines before my discovery at Lake Taal].

Habitats: Littoral; *P. litoralis* has been recorded from marine, brackish and freshwater habitats on beaches and estuaries, often under seaweed debris. Part of shore psammon (i.e., organisms growing on, in or moving through sand) or limicolous (in mud). Stephenson (1923: 182) describes habitats in damp mud under stones at edge of Chilka Lake, East Coast of India; in wet sand or sand mixed with mud both in the main area and in the outer channel of the lake - the water being either fresh, brackish, or as salty as that of the Bay of Bengal. Gates (1972) has this species from under logs on sandy soil away from shore (Burma). Under algae thrown up by waves on beach (Palmyra) and in mud with high oragnic matter and salt (10%) (Laysan). Also from mangrove swamps and sandy beaches at level of tide (the worms probably migrate with the tide). In Jogashima beach found with isopods, myriapods and nematodes, that is, the usual components of soil ecosystem, despite being in a littoral situation just above breaking waves.

Registration No.: ANIC:RB.98.2.60 (mature, figured), AM:W24571 (mature dissected and internal organs sketched), "*Mangrove Swamp Apple Tree Bay 1 Dec 1972 P. Lucas-Smith No. 4*" "*Annelids found under a rock covered at high tide. Ref. colln. No 12*" location near Boddin Head, NSW (33°38'S 151°09'E). AM:W197309

"Botany Bay J.H. Wright" "*Pontodrilus litoralis* (Grube, 1879) Id. E. Easton" (4 specimens all aclitellate, I dissected). Korean NIBR specimens yet to be registered.

Behaviour: Arenicolous (beach-living) said by Gates (1982) to ingest sand, quartz grains or "*coral fragments, foraminifera, larval pelecypod and gastropod shells*"; exudes bioluminescent mucus when disturbed, this first discovered at Tomioka, Yokohama (Kanda, 1938) in specimens identified as *P. matsushimensis*. The worms writhe and coil when placed in seawater, and placing in fresh tapwater elicits the same response (pers. obs.). There is some report of antibacterial properties [R. Gonzalez (2004) http://www.asovac.uc.edu.ve/consulta_ordenada.php?res=0&tipo=t]. Considered by Gates (1982: 34) to be at least partly parthenogenetic.

Length: 45-55 mm [cf. Gates (1972: 47, 1982: 33) <83; Easton (1984): 32-120 mm].

Width: 2 mm (cf. 2-4).

Segments: Ca. 110 (cf. Gates, Easton, 74-120), some secondary annulation in anterior.

Colour: Pale unpigmented/light grey-green, almost transparent in EtOH; clitellum red-brown.

Prostomium: Small, open epilobous.

First dorsal pore: None.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment, widely paired, ab absent on 18; (ratio from Easton: 11:4:10:9:25:82). Penial setae absent but setae may be ornamented.

Nephropores: Small near b lines from 12/13 (not in 13/14?); Michaelsen has them in setal a lines.

Clitellum: ½12,13-17, saddle-shaped (cf. Easton, 13-17,18 "annular").

Male pores: Just lateral of b lines on small porophores in ab ventral of infolded longitudinal depression of male field on 18. Setae a are occluded and ventral pairs may converge slightly around male pores.

Female pores: Paired on slightly tumid pad anterior to aa of 14 or in ab lines, (cf. Easton, in b lines on 14 in place of nephridiopores in a or b lines).

Spermathecal pores: Prominent in b lines of 7/8 and 8/9.

Genital markings: Weak pad midventrally in 12/13, plus large sucker-like depressions in 19/20 and sometimes 20/21, (cf. Easton, in some of 11/12-16/17 and/or 19/20/21); no glandular tissue associated with markings internally.

Septa: 5/6 to base of weak gizzard, then 6/7-12/13 with some thickening.

Dorsal blood vessel: Single.

Hearts: Seen in 10-13, (cf. Easton, 7-13).

Gizzards: Compact and almost vestigial in 5.

Calciferous glands: None.

Intestine origin (caeca, typhlosole): In 17 (cf. Easton,15-18) oesophagus narrow in 14-15 and perhaps valvular in 16; typhlosole absent.

Nephridia: 'Discoidal', lacking in 1-12 and 14, small in 13 then each segment has a pair of thick and coiled tubules, approximately in b lines, smaller after clitellum; pre-septal funnels seen (not that that means anything important).

Male organs: Testes/funnels in 10 and 11 usually iridescent; seminal vesicles large almost filling segments 11 and 12.

Ovaries: As long egg-strings or sheets in 13, ovisacs not seen; (nephridia absent 14).

Prostates: Single pair in 18, muscular duct, often curving and narrowed at each end, from tubular glands of approximately same length and width to muscular body wall surrounding male pores. Penial setae absent.

Spermathecae: Paired in 8 and 9, each with slightly bulbous duct to ampulla with a long clavate diverticulum (iridescent) that reaches almost to top of ampulla opening into duct close to body wall (Stephenson says it is sometimes implanted into body-wall).

Gut contents: Beach sand grains or mud and coarse coral debris.

Cocoons: Reported by Subba Rao & Ganapati (1974) from a local harbour near Waltair (also called Vizag), Andhra Pradesh, India as being spindle-shaped and green in colour and measuring 3-7 mm long by 2-3.5 mm diameter. These cocoons "*lie free on the surface layers of the sediment, not exceeding 15 cm in depth. They are also found loosely adhering to the undersurface of pebbles and detritus matter on rocks and they are often found attached to floating twigs and similar structures. During peak periods of cocoon shedding as many as 750-1825 cocoons were collected from a square metre from the intertidal habitat of the worm.*" Nearby are beaches and port of Visakhapatnam, formerly Waltair (Vizag) where a Duch fort was built in 1661 and that later came under French, then British influence in the 18th Century. The area has a history of trade (probably using sand ballast) as well as the report of floating cocoons may allow a combination of both mechanisms to explain long range and local distribution of the species. Cocoon production lasts from November to June in India. The idea of being transported by birds or along with "*soil attached to imported garden plants and vegetables*" as suggested by some workers, are both unlikely.

Gates (1982: 34) also described cocoons (of "*P. bermudensis*") as being 5 by 2 mm, but 8 mm long if he included the appendages that that are thin and coming to a

point on one end and at the other end thicker and shorter with a rather spatula-like tip.

Remarks: The above description of almost identical specimens from NSW, Galapagos Islands and from Asia differs slightly from Easton's diagnosis, but conform closely to Lee's (1959:338) précis of *Pontodrilus matsushimensis chathamianus* and Gates' (1972: 47-48) *Pontodrilus bermudensis* (both now in the synonymy of *P. litoralis*), as the female pores are closer to setal a lines (rather than b), the clitellum is saddle-shaped (rather than annular which may be a mistake by Easton), male pores are laterally bordered by clefts, marking are midventral in (12/13 and) 19/20 (20/21), and the spermathecal diverticula are clavate and as long as the ampullae.

For further diagnosis, distribution, and synonymy, see Michaelsen (1910c: 83-93) and Easton (1984: 114-116). Some ecological data and other information are provided by Lee (1969: 354; 1985: 66), Gates (1972: 48), and Subba Rao & Ganapati (1974: 18), Takeuchi (1980); salinity preference (25‰) and pesticide toxicities by Ganapati & SubbaRao (1972), Musmesi *et al.* (1992) and by Vijaya *et al.* (2002). A gregarine parasite is *Monocystis pontodrili* Subbarao, Kalavati & Narasimhamurti, 1979. Little else is yet known of the ecology and life cycle of this unusual species.

Mature specimens were collected from Jogashima south beach on 15.VIII.2003 that survived captivity in beach sand sample in the lab for >4 months. Subsequent trips to Miura peninsular yielded only juveniles (or aclitellate, regressed adults) in October, 2004. In April, 2005 some clitellates were found, but no cocoons. At Uraga further north on Miura dense populations under seaweed that although including clitellate matures, failed to provide cocoons using flotation extraction. Incidentally, I washed sand off the mature worms I collected in sea water and they seemed to only react slightly, certainly it was not instantly fatal to them.

Recently, Coupland & McDonald (2008) report high populations of *P. litoralis* of 750-4,875 m^{-2} under wrack material on arid beaches in Western Australia and they calculated that earthworms could consume approximately 19- 31 kg m^{-2} yr^{-1} organic material there. Such activity may partially account for the rapid disappearance of seaweed and other organic debris from beaches where these worms are plentiful.

Cf. ***Pontodrilus sinensis*** Chen & Zhifang, 1977: 23. **Diagnosis:** L.30.5-41.0 mm., D.1.2-1.8 mm., segs. 67-94 (type:36.5mm., 1.5 mm., segs. 93). No dorsal pores. Clitellum saddle-shaped 13-18, or only part of 18. Setae 4 pairs per segment, aa=2.5-3ab,bc=cd=2ab,aabc,dd:<1/2 of body circumference.

Genus ***Perionyx*** Perrier, 1872

Perionyx Perrier, 1872: 126; Michaelsen, 1900: 207.

Type-species: *Perionyx excavatus* Perrier, 1872: 126 from Vietnam (Saigon?).

Diagnosis (after Michaselsen, 1900; Gates, 1972, 1982): Setae numerous. Gizzard absent or reduced in 5 or 6. Digestive system without caeca, calciferous glands and typhlosole but with calciferous tissues in some portion of the oesophagus. Latero-oesophageal hearts in 10-12. Prostates and male pores in 18. Prostates non-tubular (racemose rosettes). Clitellum annular from before segment 14 for 3-7 segments (setae always retained?). Holonephridia with preseptal funnels (as is usual).

Distribution: Philippines, Sunda, (Zanzibar?), Burma, Indian regions. *Perionyx excavatus*, *P. macintoshii*, P. *sansibaricus*, and *P. violaceus* are peregrine outside this home territory. *Perionyx ceylanensis* Michaelsen, 1903 is distributed deliberately for vermicomposting.

Remarks: Gates (1972) remarks on "*amazing plasticity*" that seems to characterise the genus had led in the past to problems of classification. This was compounded by "*somatic plasticity*" expressed as heteromorphism resulting from a remarkable regenerative capacity in certain species: both head and tail regeneration are possible from almost any level of bisection (even of small living portions of putrescent 'individuals').

At one time representative of the Family **Perionycidae** Benham, 1890 that is still available as a sub-family name.

Key to Peregrine *Perionyx*

1. Three pairs of spermathecal pores in 6/7/8/9..……. *Perionyx sansibaricus* Michaelsen, 1891 - introduced to Zanzibar from its Indian homeland that is closely similar to the vermicomposting *Perionyx ceylanensis* Michaelsen, 1903.
   Two pairs of spermathecae in 7/8/9.....……..2
2. Spermathecae without extramural diverticulum; size > 300 mm ….. *Perionyx macintoshii* Beddard, 1883. [Emend. name corrected from "*m'intoshii*" Beddard, 1883 by Beddard (1893; 1895; 1889)] – from Assam, Bengal, India and (?endemic to) Akyab, Myanmar (?and Nepal Valley).
   Spermathecae with diverticulum (often attached to duct); <30 mm ……3
3. Penial setae in rings within male pores..... *Perionyx excavatus* Perrier, 1872
   Penial setae absent..... *Perionyx violaceus* Horst, 1893 - reported from Java, Sumatra, Malaya and Singapore by Gates (1972: 138) [non

Perichaeta violacea Beddard, 1895 (? = *Pithemera violacea*)], probably also of Indian origin.

Perionyx excavatus Perrier, 1872

Fig. 2.2 *Perionyx excavatus* (a) ventral view, (b) prostate with vas deferens joining duct, (c) spermathecae.

Perionyx excavatus Perrier, 1872: 126, figs. 73, 74. [Type locality in Vietnam possibly Saigon! Types in Paris Museum]; Michaelsen, 1900: 208 (syn. *gruenewaldi*); Stephenson, 1932: 50; Gates, 1972: 141 (syn. *fulvus*, ?*koboensis*, ?*turaensis*), 1982: 36; Sims & Gerard, 1985: 134 (syn. *Perionyx sp.* Friend).

Perionyx gruenewaldi Michaelsen, 1891: 33. [Types Leiden and Hamburg, 1914].

Perionyx intermedius Beddard, 1892: 689. [Types?].

Perionyx sp. Friend, 1911:188.

?Perionyx koboensis Stephenson, 1914: 391. [From the Abor Country (Himalayas). Types British Museum 1912:5:12:110].

Perionyx parvulus Stephenson, 1916: 321, fig. 15 [Types in Calcutta]; (syonymy by Stephenson, 1923: 330).

Perionyx fulvus Stephenson, 1916: 322. [Types lost].

?*Perionyx shillongensis* Stephenson, 1920: 213. [From Shillong, Assam. Type Indian Museum]; Gates, 1972:146.

?*Perionyx turaensis* Stephenson, 1920: 216. [From Tura, Assam. Types Indian Museum]; Gates, 1972:147 (possible synonym of *excavatus*).

Note on Type-locality of *Perionyx excavatus*: Perrier (1872: 129) says "*Les echantillons de ces vers que possede le museum ont ete recueillis a la demand de M. Victor Borie, alors directeur du Comptoir d'escompte de Paris par l'agence que cet etablissement possede a Saigon. Ils sont originaires de ce pays, ou ils s'appellent en annamite: Trung Khoan Co, et y ont ete par consequent distingues des vrais Perichaeta, qui se nomment Trung Com*." - The samples of these worms that the Museum owns were collected on demands of Mr. Victor Borie, director of the CEP Bank by the agency that owns this establishment in Saigon. They are native to the country where they are called in Annamese: *Khoan Trung Co* and have therefore been distinguished from real *Perichaeta* which are called *Trung Com*. I.e., samples not necessarily from Saigon city

although a footnote to Perrier (1872: 48) states that Mr Borie arranged agents to collect worms, notably from Alexandria, Saigon and Shanghai.

Distribution: Vietnam, Andaman Islands, Bangladesh, India, Sri Lanka, Seychelles (Gerlech, 2011: 62), Myanmar, Malaysia, Indonesia, Borneo, Philippines, Taiwan, Japan (Nakamura & Zicsi, 1999), Korea, Hawaii, Mexico, West Indies, e.g., Dominica (Gates) and Cuba (Fragoso pers. comm.), introduced into South Africa (Hallatt *et al.* 1990, 1992; Reinecke *et al*. 1992); also Madagascar, Reunion, Comoro, Samoa, Fiji, U.K., U.S.A., Australia and New Zealand. These last two Australiasian regions are new records by RJB [the claim by Omodeo (1956: 325) that Michaelsen (1910) recorded it from Auckland Isles (south of N.Z.) is a mistake, likely for *Perionyx shoeanus* Cognetti, 1912 now in *Perionychella*]. Rarely reported from northern Europe, e.g. from Denmark on Skov-og Naturstyrelsen database on introduced taxa www.skovognatur.dk/natur/invasive_arter/images/introarter.xls Jan., 2007]. Original home of this species is believed to be in the Himalayas, but deliberate or accidental transportation has greatly extended its range, e.g. by vermiculture operations. However, as with other members of the genus, *P. excavatus* has been recorded from under bark of standing and fallen trees and in leaf axils, thus it is not improbable that drifting logs may be account for some oceanic transportation. I found it in banana stumps on Cook Isles.

Locality: Several specimens provided by G. Bosanquet, from a Brisbane worm farm; two separate batches collected by F. Clarke (Feb/1992) and D. Murphy, (Nov/1991 and May 1993); J. Hirth 14.XI.1994; Megan Maher, 1.VII.1997; John Eades of Menai; P. Fraser of NZ, June, 2001. From worm farms in Brisbane and Mackay, Qld, Maryborough and Macleod, Vict, Broken Hill (J. Buckerfield pers. comm.); wormfarms in ACT (pers. obs); wormfarm at Menai, NSW and under manure and straw mulch of native nursery at Budderoo at some distance, but in sight of worm farm on same property; Adelaide, SA, Perth and Hobart, Tasmania. Rarotonga, Cook Islands in banana stumps. All new records for Australia, New Zealand and Cook Islands.

Habitats: Often from moist, organic habitats such as in epiphytes or under tree bark, moss, ferns, stones and logs, in gutters of buildings as many as four stories high, Dhobie compounds, mud at edge of lake and under 1m of water, paddy field (Gates, 1972). Stephenson (1933) records this species from Fort Hertz at 2,000 ft on the Burma-Tibet border, under bark of dead tree in moist rotten wood. In the present study found in piles of horse manure, in wormbeds of wormfarms, organic garden soil; and in banana stumps. Sims & Gerard (1985) say this species is tolerant of low pH situations and is employed

in the breakdown of pig slurry and as a protein source for livestock.

Registration No.: ANIC:RB.95.9.3, ANIC:RB.95.10.1, ANIC:RB.95.11.1; ANIC:RB.97.4.5; QVM 14:3663 (all specimens donated by current author).

Behaviour: Moves rapidly to escape handling, flattens body and moves back and forth, also sometimes has a lashing response and autotomy of tail. Wanders at night.

Length: 31-180 mm, body dorso-ventrally flattened with tapering tail.

Width: 2-5 mm.

Segments: 106-178, (pharynx may be everted on preservation).

Colour: Anterior dorsum violet-red with blue iridescence; ventrum pale cream (spermathecae show through) especially 13-17; clitellum darker or lighter.

Prostomium: Open epilobous, faint or slight ventral cleft on peristomium.

First dorsal pore: 4/5 (or 5/6), partly occluded on clitellum.

Setae: Small black and numerous per segment from 2: 44 on 12, 40-54 on 20; no noticeable mid-ventral gap but narrow mid-dorsal gap. No setae between confluent male pores but tips of black penial setae present around male pores.

Nephropores: Not obvious, but sometimes seen laterally, especially on clitellum.

Clitellum: Annular usually 13-17 but sometimes encroaches on adjacent segments; furrows and setae faintly retained.

Male pores: On 18 closely-paired in deep wedge-shaped clefts in a common depressed but tumid field. Tips of 5 or 6 black penial setae present encircling interior of each cleft when held open, suggesting that male pores are eversible during amphimixis.

Female pores: Single central anterior to setal arc on 14 near 13/14.

Spermathecal pores: Two pairs in 7/8 and 8/9 on anterior margin of segments: large, open pores with intervening furrows obliterated, same width apart as male pores.

Genital markings: None (darker patches median and just anterior to 3/4 and 4/5 seen in one specimen).

Septa: 7/8 and 8/9 have some thickening others weak, 9/10-11/12 appear to incorporate seminal vesicles.

Dorsal blood vessel: Single continuous on pharynx; ventral vessel also present plus a subeural vessel in clitellar region in 14-17,18 that collects from a further pair of sub-oesophageal vessels in 9-13.

Hearts: Latero-oesophageal hearts in 9-12,13 with commissurals anteriorly, supraoesophageal (with lateral vessels?) in 9-13.

Gizzard: Absent or rudimentary in (5? or) 6.

Calciferous glands: In 10-12 the oesophagus is swollen and vascularised, while in 13 it is especially swollen to almost form lateral pouches, the internal surfaces have (calciferous?) ridges.

Intestine origin (caeca, typhlosole): Origin in 16, 17 or 18; oesophagus possibly valvular in 14-16; acaecate, atyphlosolate.

Nephridia: Holoic, convoluted tubules obvious in the clitellar region but smaller anteriorly as segmentally-paired, convoluted tubules invested in mucus. Avesiculate.

Male organs: Testes/funnels large iridescent paired in 10 and 11, free or incorporated in opalescent seminal vesicle sacs of 9-12.

Ovaries: In 13 as large pair of palmate to saccular glands with numerous egg strings.

Prostates: Large almost spherical racemose glands with central U-bent duct joined entally by vas deferens, or conical by folding around thick duct, confined to 18. Penial setae visible by male pores.

Spermathecae: In 8 and 9 paired with large tapering or bilobed ampullae each with various closely-attached flat or lobed iridescent diverticula; duct short and stout. (In one specimen the diverticulum was missing but there was an iridescent seminal chamber inside the ampulla in segment 8).

Gut contents: Mainly organic material/compost.

Notes: Anterior segments may be invested in mucus internally, and dark bodies frequently seen. From my notes, there are some intraspecific variations in vascular and vesicular allocations. In glasshouse trials of the current study, this species was often found to vacate experimental soil cores and therefore its effects on plant growth were inconclusive.

Remarks: The remarkable regenerative capacity found in this genus may be responsible for the anomalous segmentation in several earlier descriptions. *Perionyx excavatus* has been recorded from tropical lowlands of Myanmar to 3,000m in the Himalayas and Gates (1972) says "*no other species of earthworm is presently known to live in so many different kinds of climates*", although this accolade is claimed for some lumbricids. It requires considerable moisture and organic matter to survive but breeds year-round, going into diapause during drought. Gates (1972) failed to observe amphimixis which has led some authors to conclude parthenogenesis despite no study as yet rearing isolated specimens to confirmed this. Moreover, spermatozoal iridescence, the presence of penial setae and widely receptive spermathecal pores suggests that sexual reproduction is a more usual option.

Perionyx macintoshii Beddard, 1883

Perionyx M'Intoshii Beddard, 1883: 217, figs. 3,8. [Type localities Akhyab. Types BMNH 1904:10.5.417].

Perionyx macintoshii : Beddard 1893: 678 [*P. macintoshii*; *P. gigas* (laps.)]; 1895: 438; 1886: 209; 1889: 209, nom nov pro (actually just a correction of) *P. m'intoshii*; Michaelsen, 1900: 208; Stephenson, 1923: 341; Gates, 1972: 144.

Perionyx m'intoshi : Michaelsen, 1900: 687; Stephenson, 1917: 383.

Distribution: Akyab (coastal Myanmar); Gora; Assam, India. From Michaelsen (1903) in shipments to Botanical gardens in Sibpur ('Seebpore'), Bengal; Nepal records are probably false (Gates, 1972: 144-145).

Diagnosis: Length 230-375 mm. Segments 200-261 (300?). Dorsum violet-brown, ventrum pale. Epilobic. Setae 33-112. Dorsal pores from 5/6/7. Nephridopores in two zig-zag lines. Clitellum 13-19 (12-23?). Male pores in lateral grooves, median on 18 (-19?) in field 3 mm wide. Spermathecal pores in 7/8/9. Gizzard large in 6. Prostates medium sized. Penial setae present. Spermathecae without extramural diverticula.

Perionyx sansibaricus Michaelsen, 1891

Perionyx sansibaricus Michaelsen 1891: 4, tab. 1, fig. 1. [Type locality Zanzibar. Types lost]; Michaelsen, 1900: 209; Stephenson, 1921: 761; 1923: 356; Gates, 1972: 138.

Distribution: Zanzibar; western, central India in the Nilgiris (in streams) and Palni Hills.

Diagnosis: Length 32-63 mm. Segments 84-108. Dorsum violet-brown, pale ventrally. Epilobic with peristomium cleft ventrally. Setae 40-56. Dorsal pores from 2/3-9/10. Nephridopores in two series on each side, i.e., alternating. Clitellum 13-17. Male pores ventro-median in depressed or ridged field. Spermathecal pores midventral in 6/7/8/9. Gizzard rudimentary in 6; intestine pouched in 13. Nephridia with terminal vesicles alternating. Prostates large, glandular. Penial setae absent. Spermathecae with small diverticula that each consist of three or four closely aggregated seminal chambers.

Notes: A closely similar, if not synonymous, species is *P. ceylanensis* Michaelsen, 1903: 6 that, however has a small gizzard in 5 and nephropores without regular alternation; it is a vermicomposting species. Neither found in current studies.

Perionyx violaceus Horst, 1893

Perionyx violaceus Horst, 1893: 72. [Type localities Java/Sumatra. Types in Leiden, 1714 and Hamburg, 9290]; Michaelsen, 1900: 209; Stephenson, 1932: 51 (misspelt "violaseus"); Gates, 1972: 138.

Distribution: Java (Buitenzorg, Tjibodas), Sumatra (Singkarah, Manindjau, Paninggahan), Malaya (Fraser's Hill), Singapore.

Diagnosis: Length 55 mm. Segments 115. Dorsum violet-brown. Epilobic. Setae 40-50. Dorsal pores from 4/5. Nephridopores in straight line. Clitellum 13-17,18. Male pores ventro-median. Spermathecal pores in 7/8/9. Gizzard rudimentary in 6. Prostates small. Penial setae absent. Spermathecae with small diverticula.

Notes: Not found in current studies (cf. *Pe. excavatus*).

Genus ***Lennoscolex*** Gates, 1960

Lennoscolex Gates, 1960: 241:1972: 135.

Type-species: *Woodwardiella pumila* Stephenson, 1931) from Bhamo, Burmah.

Diagnosis: Setae lumbricine (only!). Male pores on 18 combined with pores of non-tubular (i.e., tubuloracemose or racemose) prostates; female pores on 14; spermathecal pores paired in 7/8-8/9. Gizzard in 5. Calciferous glands, typhlosole and intestinal caeca absent. Hearts in 10-12 or 13(!). Nephridia meroic (at least in anterior), avesiculate. Spermathecae diverticulate (as would be expected). Clitellum annular. Holandric. Dorsal pores present.

Note: The genera names *Lennoscolex* Gates, 1960 and *Lennogaster* Gates, 1939 are easily confused (just as with *Nelloscolex* Gates, 1939 and *Nellogaster* Gates, 1938). Of the type-species, Gates (1942) found: "*On some of the Rangoon specimens, especially on the clitellum and around the male pores, there are clusters of rotifers. These were sent to the British Museum but have not been further identified*."

Distribution: Southern India; the type-species and *N. javanica* recorded in Myanmar and the latter species also reported from Java, Indonesia, both locations by introduction.

Remarks: The generic diagnosis is almost identical to Australian/NZ *Notoscolex* Fletcher, 1886: 546 (as revised by Blakemore, 2000; 2006/7) into which several Indian (and North American!) species were formerly put. Gates (1960) comments that the definition is tentative but that: "Notoscolex minimus, peermadensis, kayankidamensis, travancorensis*, all of Aiyer, 1929 and* tenmalai *(Michaelsen, 1910) appear to be candidates for inclusion in the genus. The digestive system, except for the extension of the esophagus posteriorly, is very simple, perhaps primitive but the meronephry of the excretory system is very advanced.*"

This genus is briefly introduced in order to list the probable peregrines

Lennoscolex javanica (Michaelsen, 1910)

Woodwardia javanica Michaelsen, 1910: 93. [Buitenzorg, Java. Types in Hamburg?].

Woodwardiella javanica : Gates, 1942: 108.

Notoscolex javanica : Gates, 1961: 57.

Lennoscolex javanica : Gates, 1960: 243; 1972:136.

Distribution: Myanmar (Boyagyi, Thaton district; Mupun, Amherst district) and Java (presumably by introduction).

Diagnosis: (from Gates, 1942; 1960; 1972): Prostomium proepilobous. Size 38-75 by 1 mm. Segments? Lumbricine with setae moving dorsally after clitellum. Clitellum 14-17. Spermathecal pores in 7/8/9 just lateral of a lines. Male pores on 18 on slight porophores. First dorsal pore at 6/7. GMs lacking. Gizzard in 5. Spermathecal diverticula clavate. Last hearts in 12. Intestine from 18. Penial setae present. Prostates racemose. Nephridia meroic.

Notes: The only differences from the type, *L. pumila* from Myanmar (and possibly South India?) that can probably collect sympatric synonyms, are the spermathecal pores are in b lines and GMs are present in 17/18-18/19 and last hearts are in 13.

Although unlikely, Gates (1942: 112) thought the species so close to Australasian *Notoscolex* that "*It is therefore possible that both the Java and Burma records indicate importations from some eastern portion of the Australasian region*."

Genus ***Lampito*** Kinberg, 1867 s. str.

Syns. *Lampita* Marshall, W., 1873 (laps.); *Megascolex* (*Perriera*) Vaillant, 1899.

Type-species: *Lampito mauritii* Kinberg, 1867 from Mauritius.

Note: Some authors, e.g. Gates (1972: 133), have date as Kinberg (1866), Michaelsen (1900: 234) has "*Kinberg, 1867 (66?)*" and Reynolds & Cook (1976) have "*1867*" which is believed to be correct (see also *Amynthas*).

Diagnosis: Setae perichaetine (only!). Male pores on 18 combined with pores of non-tubular (i.e., tubuloracemose or racemose) prostates; female pores on 14; spermathecal pores paired. Gizzard in 5. Calciferous lamellae in oesophagus in 10-13. Typhlosole present, intestinal caeca absent. Hearts in 10-13. Nephridia meroic (at least in anterior), avesiculate. Spermathecae two or three pairs in 7-9, each with a lateral and median digiform diverticulum.

Distribution: Palni and Cardomom Hills, South India, the type-species transported further being recorded from the tropics of the Indo-asiatic region, Pacific Isles and Indian Ocean Recent reports of two '*Lampito*' species from Ceylon in Pakistan (Ref.) are for *Megascolex templetonianus* Rosa, 1892 and *M. willeyi* Michaelsen, 1909.

Remarks: Michaelsen (1900) and Stephenson (1923) merged the genus in *Megascolex*, but it may be separable on its doubled spermathecal diverticula. The current revision restricts to perichaetine setae only, as found in the type for which Gates (1972: 135) remarked "L. mauritii *does not appear to be closely related to any of the known species of the genus*." Of the half dozen species included when the diagnosis of *Lampito s. lat.* had permitted them, those with lumbricine setae (e.g. *Notoscolex palniensis* Stephenson, 1924) will require return or reallocation to other genera, such as *Lennoscolex* Gates, 1960 (type *Woodwardiella pumila* Stephenson, 1931), or to *Notoscolex* Fletcher 1886 (type *Notoscolex camdenensis* Fletcher, 1886 from Burrawang, NSW). Blakemore (2006/7) has already returned several Indian taxa to *Notoscolex*. Albeit Gates (1972: 132) questioned whether Indian species actually belong in *Notoscolex*, its genus range now includes New Zealand for species with non-tubular prostates that were previously placed in *Megascolides* McCoy, 1878 (see Blakemore, 2005; 2007 and Blakemore in Lee *et al.* 2000).

Lampito mauritii mauritii Kinberg, 1867

Lampito mauritii Kinberg, 1867: 103. [Type locality Mauritius. Types in Stockholm: 162]. [Sometimes dated "*Kinberg, 1866*"]; Stephenson, 1916: 315; 1923: 259 (syns. *armatus* Beddard, 1883; *bivaginata* Bourne, 1886; *salettensis* Bourne, 1886), Gates, 1960: 243; 1972: 133 (syn. *armatus*, *madagascariensis*, *trilobatus*); Sims & Easton, 1972: 206 (syn. *luzonica*). [Non *Perichaeta mauritiana* Beddard, 1892 (?= *Amynthas gracilis*)].

Perichaeta luzonica Perrier, 1875: 1044. [Designated type-species of the overlooked sub-genus *Megascolex* (*Perriera*) Vaillant, 1899 by Sims & Easton (1972: 205) thereby preventing this subgenus from competing for priority with other genera. Note: Conflicting data is by Jamieson (1975: 139) who lists Paris "*TYPE of luzonica (part.)*" as AE629 (ex A724) from "*de Bataan, Ile Lucon*" collected by M. Laglaize on "29 9bre *1875*" in synonymy of *Lampito mauritii* although this is immediately confused with AE630 of *L. mauritii* from Pondichery, and Jamieson (1975: 140, 141) on the next two pages also lists AE634 (ex A724) as "*TYPES of P. luzonica*" with same collection details as AE 629 (or, on p. 141, with AE634 from "*Lucon, Mindoro*" – a different locality and mistakenly by "*Perrier (1875: 1)*") in synonymy of *Polypheretima elongata*! Latter synonym and types are likely

mistakes although Reynolds & Cook (1976: 131) also list MNHN 634 as type of *luzonica* perhaps also confused by Jameison's contradictions – cf. *P. affinis*].

?Perichaeta coerulea Perrier 1875: 1044. [From Luzon, types in Paris 631-2]. [Non *Megascolex coerulea* Bourne, 1891: 49 (laps. = *Megascolex caeruleus* Templeton, 1844, the type-species of the genus)].

Perichaeta armata Beddard, 1883: 216, figs. 5-7. [From Calcutta. Types BM.1904.10.5.5 etc.].

Megascolex armatus : Horst, 1893: 71, figs. 31-32; Beddard, 1895: 69. [From Indonesia and north Borneo]. Note: This mention by Horst mistakenly noted as a new taxon in Reynolds & Cook (1976: 72)]; Michaelsen, 1897: 5 (syn. *madagascariensis*).

Perichaeta bivaginata Bourne, 1886/7: 666. [Types?].

Perichaeta salettensis Bourne, 1886/7: 669. [Types?].

?Megascolex perrieri Vaillant, 1889: 71. [Types?].

Perichaeta madagascariensis Michaelsen, 1891: 227. [Type Hamburg, 924].

Megascolex mauritii: Michaelsen, 1899: 441; 1900: 227 (syns. *armatus*, ?*coerulea* + *luzonica*, *bivaginata* + *salettensis*, ?*perrieri* + *luzonicus*, *madagascariensis*); Beddard, 1906: 375 .

Note: For full synonymies see Michaelsen (1900), Stephenson (1923), and Gates (1972) whence the following description is extracted.

Diagnosis: Megascolecidae with racemose prostates to male pores on 18 paired in large circular porophores (with penial setae). Spermathecal pores paired in 6/7/8/9, spermathecae large and bidiverticulate. Setae perichaetine. Nephridia meroic. Gizzard in 5-6. No intestinal caeca.

Distribution: Mauritius, Seychelles, Diego Garcia (Sims, 1971), Comoros Islands, Madagascar, Zanzibar, India, Bangladesh, Pakistan (Ref.), Sri Lanka, Andaman Islands, Maldives, Laccadives, Myanmar, Thailand, Malaysia, Vietnam [reported as "*L. maurriti*" (laps.) and abundant in sandy soil], Laos, Cambodia, Singapore (e.g. Rosa, 1891: 404), Sumatra, Christmas Island south of Java (Michaelsen, 1935a), Java, Sumba, Kisser Island, Nias, Borneo (e.g. Padas Valley), Philippines, Hainan, China (Hong Kong and Kowloon), New Caledonia, and a report (pg. 97) from Hawaii. Possibly listed erroneously as "*Metaphire luzonica* (Perrier, 1875)" from European databases [http://www.faunaeur.org/full_results.php?id=177940 May, 2006 and http://eunis.eea.europa.eu/species/223356 Jan, 2011, this possibly related to Darwin's

report of "*Perichaeta luzonica*" identified by Perrier from Nice – see discussions above]. Mainly tropical, in higlands and coastal lowland. This species has not as yet been reported from Australia (except Christmas Island south of Java in the Indian Ocean), however its presence in adjacent regions and islands suggest it has the potential for colonization.

Habitat: Soil, manure heaps, plant pots.

Behaviour: Luminescent ejecta and alarm pheremones secreted; geophagous and/or detritivorous; produces pellet-like casts.

Length: 80-210.

Width: 2.5-5 mm.

Segments: 157-201.

Colour: Greyish to yellow-brown.

Prostomium: Prolobous or epilobous.

First dorsal pore: In region of 10/11-12/13.

Setae: Numerous but variable in number up to 50 per segment (fewer on 17-19); median setae on each side of 18 penial; ventral setal gap with setae a-d enlarged, at least in anterior.

Nephropores: ?.

Clitellum: Annular 13,14-17, furrows and setae faintly retained.

Male pores: On 18 paired on large circular porophores that extend from setal lines a-d.

Female pores: Paired (rarely single) on 14.

Spermathecal pores: Three pairs in 6/7-8/9 in setal lines e-h, the pores larger than the female pores.

Genital markings: None.

Septa: Some of 6/7/8-11/12/13 thickened.

Dorsal blood vessel: Single.

Hearts: In 10-13, with commissurals in 5-9.

Gizzard: In 5 (Gates), 5 or ?6 (Stephenson), or 6 (Michaelsen).

Calciferous glands: Oesophagus in 10-13 with internal lamellae; no calciferous glands.

Intestine origin (caeca, typhlosole): 15 or 16 (Gates); intestinal caeca absent, typhlosole quite insignificant.

Nephridia: Meroic, avesiculate; some enteronephic into gut in posterior segments.

Male organs: Testes/funnels paired in 10 and 11, seminal vesicles in 9 and 12.

Ovaries: Fan-shaped with several egg-strings in 13; oviascs small, acinous in 14.

Prostates: Large racemose (or tubuloracemose?) in 18-19 with muscular ducts; penial setae present.

Spermathecae: In 7-9 paired with barrel-shaped duct as wide but shorter than the ampulla, two small digitiform diverticula from lateral and median faces of each duct.

Gut contents: ?

Remarks: Gates (1972: 135) comments on the regenerative capacity of this species with head regeneration possible in an anterior direction at all levels back to 25/26 (sometimes due to internal head amputation by parasitic insect larvae of *Sarcophaga* sp.). In India, Ismail (1997) discusses the ability of this species to recycle organic matter and to ameliorate poor soils, including highly alkaline sodic soils. This characeristic perhaps explains why Gates (1960) says it has been "*avidely exported*" from southern India.

Stephenson (1923) reported a variation, *L. mauritii zeylandicus* (Stephenson, 1913) from Anuradhapura, Sri Lanka, that differed by having wider setal breaks (aa=3ab); accessory prostates near the main glands, one on each side; and spermathecae without defined ducts but with one or two minute diverticula.

Anisochaeta Beddard, 1890.

Megascolex (part.); Beddard, 1890: 56; 1895: 381; Michaelsen, 1900: 212; 1907: 163; Stephenson, 1930: 837; Gates, 1965; Jamieson, 1974: 318.

Perichaeta (part.); Beddard, 1890: 56.

Anisochaeta Beddard, 1890: 56; Blakemore, 1997a: 1685; b: 1822; 2000a: 2; b: 5; c.

Trichaeta Spencer, 1900: 30.

Spenceriella Michaelsen, 1907: 160.

Gemascolex Edmonds and Jamieson, 1973: 23.

Propheretima Jamieson, 1975, 589.

Diagnosis: Anisochaetine or perichaetine (i.e., setae 8 per segment in the anterior, increasing posteriorly, or more than 8 throughout). Female pores, single or paired on 14. Male pores from tubuloracemose or racemose prostates paired on 18. Dorsal pores present, or absent (eg. in *A. mawbanna* sp. nov.). An oesophageal gizzard in 5 or 6 (large and almost divided in two in *A. zeehan*, or not developed, eg. in *A. clavi*). Nephridia meroic, at least in the fore-body, avesiculate or vesiculate, often tufted in the anterior. Spermathecae one or more pairs (sometimes unpaired), with one or more diverticula that are clavate, bifid, or sometimes multiloculate (eg. in *A. alba*, *A.brevis*, *A. floris*, *A. isla*, and *A. portusarturi*). Calciferous glands and typhlosole present or absent; intestinal caeca and gizzards absent. Penial setae present or absent. Segmental and intersegmental genital markings usually present but sometimes reduced or absent (eg. *A. sebastiani*).

Type-species: *Perichaeta coxii* Fletcher, 1886: 565-659; Fletcher, 1889: 1554.

Distribution: Australia, all states (Beddard, 1890, Blakemore, 2000a), and New Zealand (Lee, 1959; Blakemore in Lee *et. al*, 2009); some species widely distributed in Australia (see Blakemore & Elton, 1994; Blakemore, 2000a) and a few are considered as cosmopolitans.

Instances are of *Anisochaeta tenax* (Fletcher, 1886) from around Sydney being reported (as *Perichaeta albida* Michaelsen, 1892) from Marquesas de Mendoza in the South Pacific (Michaelsen, 1900: 226), and *Anisochaeta laingii* (Benham, 1903) from Norfolk Island that has been recorded from Hamilton, New Zealand (Gates, 1965; Blakemore, 1997b; Lee *et al*., 2000), and Raoul in Kermadecs but possibly misidentified there. *A. minor* (Spencer, 1900) was apparently transported in reverse to Scotland according to Sims & Gerard (1985, 1999). Because of this it is briefly described below. *A. macleayi* was recently found in New Zealand by the current

author (details below).

Included species: In New Zealand, three species transferred from *Megascolex* are from the North Island and one from Norfolk Island (Blakemore, 1997a,b, 2004). In Australia, approximately 117 species have been described: 10 from SA, 21 from Vict., 50 from NSW, 14 from WA, 18 from Qld, with 4 previously described from Tasmania. An additional 20 species from Tasmania were described by Blakemore (2000) bringing the generic total to approximately 137 species, making this the largest genus in Australia. Some species' natural distributions cross State boundaries and some are widely translocated (see Blakemore & Elton, 1994; Blakemore, 1997a,c; 2000a,b).

Note: Gates (1965) draws attention to the regenerative capacity of the species, which often results in somatic variations. Such capacity may compliment the autotomy observed for specimens here. The autotomy in turn may be an adaptation to avoid predation suggesting that this species is naturally litter dwelling near the surface, a conclusion supported by its diet and dark red pigmentation.

Taxonomic Remarks: The most recent revisions of this genus are by Blakemore (1997a,b; 2000a,b; 2006a,b; 2010), where the above synonymies are discussed. *Perichaeta* has long been subsumed (see Stephenson, 1930), and formal separation from *Megascolex* was proposed by Blakemore (1997a,b). [Note: Notwithstanding morphological grounds, there is precedence to separate genera mainly on geographical grounds too for 'conveninence' such as when Michaelsen (1921) split *Octochaetus* in NZ from *Octochaetoides* in India]. Monotypic *Trichaeta*, established by Spencer (1900) for his Victorian *Trichaeta australis* (now *Anisochaeta trichaeta* Blakemore, 2000b - renamed due to junior secondary homonymy of *Anisochaeta australis* (Fletcher, 1886)), was placed in synonymy of *Megascolex* by Michaelsen, 1907 and is now included under *Anisochaeta*. There is some distpute about inclusion of the genus *Spenceriella* as discussed by Blakemore (2000) in Tasmanian Earthworms publication.

The synonymy of *Propheretima*, a genus based on one first proposed by G. Dyne (unpublished Qld University PhD thesis, 1984: 375-376) just as the genus *Hiatidrilus* matched one proposed in a Qld Uni PhD thesis by Blakemore (10th March, 1994: 478-480) and by Blakemore (1994 in a manuscript submitted but rejected after a lengthy delay due to an 'anonymous' hostile referees report!). Synonymy was advocated and then formalized by Blakemore (1997a: 1686; 1997b: 1838-1839; 2000a: 38). This genus *Propheretima* was defined with a type-species that is a probable junior synonym of *Anisochaeta newcombei* (Beddard, 1887) (see Blakemore,

1994; 1997b: 1843) and rightly complies with the diagnosis of prior *Anisocheta* above.

Keys to species are provided by Blakemore (1994, 2000, 2006, 2008 - these latter online). The cosmopolitan species are not keyed out here as Blakemore (1994) noted that: "*The endemic genus* Spenceriella [= *Anisochaetai*] *has many unnamed and morphologically similar species, often differing intraspecifically* [here I meant 'interspecifically'] *in the distribution of genital markings.*"

Thus a key to just the know species may be premature/incomplete.

Anisochaeta laingii (Benham, 1903)

Fig. 2.2.1 (Benham, 1903, copies with RSNZ permission for comparison only).

Megascolex laingii Benham, 1903: 273, Pl. XXII (body diagramatics), XXVI, fig. 1 (spermatheca).

Megascolex laingii; Michaelsen, 1907: 163; Lee, 1952: 38; 1959: 283, fig. 305 (spermatheca after Benham); Gates, 1956 [synonymy under *M. newcombei* (Beddard, 1887)].

Spenceriella laingii ; Blakemore, 1994: 530 (questions synonymy with *S. newcombei*).

Anisochaeta laingii; Blakemore, 2004; 2005; 2010 (restored); 2016.

Types: Two anterior fragments, their location now unknown.

Distribution: From Norfolk Island, also claimed from Hamilton, New Zealand (Gates, 1965; Blakemore, 1997b; Lee *et al*., 2000) and from Raoul Island in the Kermadecs according to amateurs Buckley *et al.* (2011), that may be questioned considering the number of similar species now known as introductions to New Zealand from Australia as found in the current study (see note on *A. kiwi* below). Not located in current surveys in Australia nor NZ.

Behaviour: ?

Length: 20+ mm (type fragmented). **Width:** ca. 2 mm. **Segments:** 28+.

Colour: Preserved it was a purplish-red, with a darker line around the middle of each segment; pale ventrally.

Prostomium: Open epilobous; ventral cleft not noted (but possibly present).

First dorsal pore: From 5/6.

Setae: Perichaetine between 16-32, increasing further posteriorly; slightly more crowded ventrally and the dorsal gap wider than the ventral.

Nephropores: Not recorded (meroic).

Clitellum: Not developed in the types.

Male pores: Superficial on small papillae on 18 in setal b lines.

Female pores: Not found in the types.

Spermathecal pores: 7/8 and 8/9 in line with setal interval bc.

Genital markings: On segments 10, 11 and 12 in line with the spermathecal pores are a series of pale areas, each with slight pitting in their centres indicationg copulatory tubercles; on 17 is a pair of "*conspicuous"* longitudinal ridges or oval papillae that meet at the median line so as to form a dumb-bell shape.

Septa: Not recorded for type.

Blood vessels: Dorsal blood vessel single.

Hearts: Last hearts in 12.

Gizzard: Small, thin-walled cylinder in 5.

Calciferous glands: Oesophagus only slightly dilated in 13 and 14, not calciferous.

Intestine origin (caeca, typhlosole): 16.

Nephridia: Meroic, with large tufted nephridia anteriorly.

Testis/seminal vesicles: Holandric, paired testis in 10 and 11 producing "*loose sperms*"; seminal vesicles paired, botryoidal in 9 and 12.

Ovaries: Normal (in 13).

Prostates: Small, paired lobulated and bilobed gland with short muscular duct; penial setae absent.

Spermathecae: Two pairs in 8 and 9 with globular ampullae each with an elongated diverticulum opening by its own duct into the short duct of the copulatory sac.

Gut contents: Not noted.

Remarks: Benham compared his species to *A. minor* (Spencer, 1900) from Queensland, obviously recognizing the close similarity to mainland forms, but his species differed on its oesophagus being dilated slightly in 13 & 14, rather than in 8-10 in Spencer's species and on distribution of genital markings. A distinctive feature, even in *A. laingii* specimens lacking clitella, is the "*conspicuous*" markings in 17 according to Benham. Subsequent acceptable variation has allowed these two taxa to merge closer morphologically (Blakemore, 1994). It is here assumed that *A. laingii* is a species introduced to Norfolk Island from Australia sometime in the past. It is comparable and possibly confused with *Anisochaeta kiwi* sub. spp. newly described by Blakemore (2012).

Anisochaeta macleayi (Fletcher, 1889)

Fig. 2.2.2 (ex Blakemore, 1994, fig. 41).

Fig. 2.2.3 *Anisochaeta macleayi* (Fletcher, 1889), Wairakei Steamfield nr well WK 44/0. Coll.: RJB, 13.IX.2011. Central specimen AMNZ 5262, rhs specimen AMNZ 5263.

Perichæta Macleayi (sic) Fletcher, 1889: 1556.

Perichæta Macleayi vars. c (i)-(iii) (?non *P. Macleayi* vars. a b) : Fletcher, 1890: 1004.

Megascolex macleayi: Beddard, 1895: 376 (part. ?).

Megascolex macleayi: Michaelsen, 1900: 223 (part. ?).

Spenceriella (Spenceriella) macleayi: Blakemore, 1994; Blakemore & Elton, 1994: 251, fig. 1.

Anisochaeta macleayi : Blakemore, 1997b, 2001; 2000: 4; 2002; 2006; 2008; 2010: 292.

Syntypes: AM W1344-1345.

Note: Fletcher (1890: 1004-2006) described three varieties and three sub-varieties of *Anisochaeta macleayi* (Fletcher, 1889). Whereas 'c' sub-varieties (from Mt Victoria, Raymond Terrace, Morpeth, Coonabarabran and Gunnedah) agree tolerably on information given to *A. macleayi* proper, varieties 'a' and 'b' (from Mt Wilson, Lawson and Burrawang) differ considerably. Thus all varieties may not be conspecific, e.g, Fletcher (1890: 1007-1008) described a possibly distinct variety of *Anisochaeta fecunda* (Fletcher, 1887) from Burrawang that is, nevertheless, similar to his "*Perichæta Macleayi var. b*" as noted by (Fletcher, 1890) also from Burrawang. Another similar species is *Anisochaeta filix* Blakemore, 2000/2006 from New England National Park, NSW that, however, is more robust (~160mm long) with more ventral spermathecal pores and slightly different distribution of its genital markings.

Distribution: "*Sydney (common in the Hon. W. Macleay's garden at Elizabeth Bay)*" – Fletcher (1889). From Mount Victoria, Blue Mountains; Raymond Terrace and Morpeth; and Coonabarabran, Gunnedah from the banks of the Namoi, all in New South Wales - Fletcher, 1890 (for variety "*c*"). Australian Museum collections (identified by E. Easton in 1983 from Mt Tomah, Queenscliff NE Sydney and Bundanoon, NSW. Reported from Richmond, NSW (Blakemore & Elton, 1994) and Deniliquin in the Riverina district, NSW (Barley & Kleinig, 1964); known also from Broulee, NSW and Oolong, Book Book (near Wagga Wagga,), NSW, also Churchill and Yea, Victoria (Blakemore, 1994; 1997; 2000; 2006), plus (Blakemore, unpub.) from Lidcombe, NSW along with *Aporrectodea longa*. Thus it is unusual for a native to have such a

particularly widespread distribution in central coastal NSW to Victoria and, now from New Zealand where it was recently recovered at Wairakei, NZ (RJB, 2011) in a drainage channel with exotic lumbricids *Aporrectodea trapezoides* and *Octolasion cyaneum*.

Material examined: Specimens from Yarrumundi Paddock 3 of the University of Western Sydney, Hawkesbury campus, near Richmond, 55 Km north-west of Sydney NSW. Collector K.L. Elton: four mature specimens (AM W21710); from Yea, Vict. and Wagga Wagga, NSW (ANIC: RB.94.20.2, RB.94.21.1), Broulee, NSW (ANIC: RB.94.23.3) and possibly Scullin, ACT (ANIC: RB.95.18.7). Plus a similar species but lacking the distinctive marking in 10 and 11 found by RJB (Jan., 2011) at Lidcombe, NSW and described as *Anisochaeta* cf. *macleayi*. Recently discovered (Sept., 2011) specimens were collected by RJB 13/9/2011 from Wairakei, NZ from drain in steam fields near well WK44/0 (three mature specimens in Auckland Museum).

Habitat: Under grazed, two year-old, sown grass/medic pasture on a red podsolic in association with *Aporrectodea trapezoides* (Blakemore & Elton, 1994); in a sandy ditch at Broulee, central coastal NSW along with *Anisochaeta sebastiani* Blakemore, 1997, *Heteroporodrilus oxleyensis* (Fletcher, 1889) and *A. trapezoides* (Dugès, 1828).

Behaviour: See note on gut contents.

Length: 40-110 mm. **Width:** ca. 4 mm. **Segments:** 83-102. Slight secondary annulation from 6. The posterior eight segments dorsally canaliculate in one specimen but often spade-shaped.

Colour: Dorsum dark, reddy to chocolate brown especially in the anterior, setal auriolae and ventrum pale, clitellum buff. Cuticle not especially iridescent.

Prostomium: Open epilobous, almost appearing tanylobous, sometimes faintly closed by a fine groove parallel and close to intersegmental furrow 1/2. Peristomium ventrally cleft.

First dorsal pore: 5/6, continuous on clitellum.

Setae: Perichaetine usually about 20 per segment but ranging up to 24, with fairly wide mid-ventral and mid-dorsal gaps. No setae between the male pores.

Nephropores: Not seen (enteronephric).

Clitellum: Annular ½13-½17, interrupted ventrally in 17, furrows and setae retained.

Male pores: Superficial as largish lateral slits equatorial on 18 on summits of a pair of opposed low porophores.

Female pores: Paired just anterior to setal arc about the width of the mid-ventral gap.

Spermathecal pores: 7/8 and 8/9 only faintly marked in deep intersegmental furrows

approximately as wide apart as male pores (i.e., in line with setae c or d).

Genital markings: In 10 and 11, a pair of raised ventral mounds extending from a to c setae, each with a translucent, ellipsoid rim to an eye-like pore or disc on the summit. The anterior pair often slightly larger. In 17, variously paired genital markings: two to four presetally, two postsetally; in 18 one or possibly more presetal mid-ventral papilla; in 19 a pair equatorially or a pair presetally and a pair postsetally with ocassional eccentric papillae. The anterior annulus of 17 and the posterior annulus of 19 are slightly tumid as they accommodate the ventral papillae often obscuring details.

Septa: 4/5 weak over gizzard, 5/6 flimsy to base of gizzard and displaced and adpressed to 6/7 by gizzard, thickening from 7/8 to 9/10 or 10/11 thereafter thinning to become membranous after 14/15.

Blood vessels: Dorsal blood vessel single, continuous onto pharynx; weak supraoesophageal vessel in 11-15.

Hearts: Commissurals 6-9, hearts 10-12.

Gizzard: Large barrel in 5, has muscular sheen but can be readily deflected.

Calciferous glands: Oesophagus slightly dilated in 8-10 and 13, especially in each of 11 and 12 to form a pair of dorsally or laterally sessile yellow calciferous glands (i.e., two pairs in 11 and 12) that however are not particularly vascularized.

Intestine origin (caeca, typhlosole): 15 or (NZ specimen) 16; acaecate, typhlosole not found.

Nephridia: Meronephric, with large tufted nephridia ventrally in 4-6 reducing to parietal forests of micromeronephridia by the clitellar region and after.

Testis/sperm funnels: Holandric: paired sacs (absent in NZ specimen) in 10 and 11 contain unusually large palmate or 'tufted' testis and non-iridescent, nebulous funnels. Seminal vesicles paired, lobulate on posterior septum of 9 and larger, racemose on anterior septum of 12.

Ovaries: In 13 as pair sets of palmate strands with numerous egg strings and diaphanous funnels.

Prostates: Large, paired lobed or S-shaped tubuloracemose glands extending over two or more segments with short flaccid duct.

Spermathecae: Two pairs in 8 and 9 with large sub-spherical or elongate ampullae tapering to ducts each bearing near ectal end a shorter, white, digiform diverticulum.

Gut contents: In NSW specimens, when the fine, yellow soil and occasional organic 'husks' were flushed away, large quartz crystals (up to 0.4 mm diameter) remained that

may serve as selectively ingested 'crop stones' for comminution of soil, alternatively they may represent involuntary ingestion of a sandy medium indicating partial geophagy.
Notes: Mucus permeated the cavity of several segments, especially 9-15 in NSW specimens that possibly is a deterrent response to nematodes.
Remarks: Fletcher described about twenty native *Perichaeta* species in addition to *A. macleayi* in a series of papers (1886a-1890). Fletcher (1889) differentiated his dozen *Perichaeta* (= *Anisochaeta*) *macleayi* specimens from Sydney NSW from those of *P.(=A.) australis* (Fletcher, 1886) from Burrawang, NSW, by their size, genital markings and possession of only two pairs of calciferous pouches in 11 and 12. The above description concurs with, and augments, this earlier account as well as providing illustrations. Representative of the genus on the whole, this species is especially differentiated by having two pairs of calciferous glands and the distinctive paired genital mounds on 10 and 11 "*each with a central pore-like depression*" - Fletcher (1889).

Of the three *A. macleayi* "*varieties*" invoked by Fletcher (1890) varieties "*a*" and "*b*" differ from the original types, not only by being larger with more segments, but also with regards to (1) the number and character of the genital markings (2) the position of the first dorsal pore and (3) spermathecal pores. Fletcher's (1890) variety "*c*", however, were of similar size and had the distinctive papillae in 10 and 11 with "*opposite the interval between the first and second setæ a pair of fossettes*". Consequently, I have included them in the synonymy of *A. macleayi* and, provisionally, excluded the other varieties (*cf.* Michaelsen, 1900). Unravelling the relationship of *A. macleayi* with the "*variety*" of *P. (=A.) fecunda* (Fletcher, 1887) with only two pairs of spermathecae (Fletcher, 1890), is not attempted here.

Perhaps these other varieties are part of a species complex, but, as with *A. macleayi* proper, none have subsequently been re-described. Barley and Kleinig (1964: 190), include this species in a footnote of species collected along watercourses near Deniliquin, NSW). It is reassuring to know that some native species, such as this one, have survived the cultivation, urbanisation and onslaught of exotic species that have occurred since the last century.

A similar species, but lacking the distinctive markings in 10 and 11, was recently collected by the author in a drainage ditch at facility in Lidcombe, NSW (coll. and ID by RJB Jan, 2011 for Fleur Pablo & Amanda Rose at NSW Dept. Environment, Climate Change and Water, Sydney). The recommendation in a report by the current author to Environment NSW that such a native earthworm would make useful model for

toxicological or agronomic testing on native soil fauna is supported by its particularly widespread distribution (although how much is self acquired is unknown) and presumed broad tolerance of environmental/edaphic conditions in that it persists under cultivation.

Specimens from New Zealand concur almost exactly with the earlier Australian descriptions, the only differences are slight markings near spermathecal pores that may be artefacts, and intestinal origin in 16 rather than 15 that may be anomalous or a miscount; but the overwhelming similarities lead to the conclusion that this is an introduced species demonstrating the transportability of this species and its survival adaptability characteristic of most Cosmopolitan Earthworms (Blakemore, 2010).

Anisochaeta kiwi subspp. Blakemore, 2012 now known from NZ's North & South Islands (e.g. Waikato & Punakaiki) are apparently as yet undescribed in their Australian homeland (Blakemore, 2012); a Kermadec report is by Chinn (2011) (listed as *Megagascolidae laingii* (sic) (= *Anisochaeta* with DNA samples agreeing with *A. kiwi*). Moreover, in 2024 a specimen confirmed with DNA was found in Hobart, Tasmania.

Anisochaeta minor (Spencer, 1900)

Fig. 2.2.3 (ex Blakemore, 1994) *A. minor* (a) ventrum (b) prostate and (c) spermathecae.

Megascolex minor Spencer, 1900: 49, Pl.8, figs. 55-57.

Megascolex minor, Sweet, 1900: 119; Michaelsen, 1916: 27; Jensz and Smith, 1969: 98.

Spenceriella minor; Blakemore, 1994; (?non Sims & Gerard, 1999: 136, fig. 49).

Anisochaeta minor; Blakemore, 1997, 2000, 2006, etc.

Types: NMV F40103, G102 (Jensz & Smith).

Distribution: Cooran, Gayndah (Spencer, 1900), Mt Tamborine, Blackall Range (Michaelsen, 1916), Lamington National Park and Localites given below.

Locality: From beside, a creek at Ban Ban Springs, under speargrass *Heteropogon contortus* pasture at DPI Brian Pastures and recovered from glasshouse pot to which these earthworms had been added.

Habitat: Various: alluvial sandy soils to cracking clays soil under pasture.

Registration No.: Numerous specimens, mature and immature.

Behaviour: Moderately luminescent, active and ejects coelomic fluid when handled. Found in the root zone under grasses.

Length: 50-70 mm.

Width: 1.5-3 mm.

Segments: 82 (post. amp.), 86-108 with secondary annulations.

Colour: Dark brick-red dorsum, anterior and posterior few segments, pale ventrum from about 6 and after clitellum, clitellum orange-brown.

Prostomium: Open epilobous to ½1 but tapering faintly to 1/2; deep ventral notch on peristomium to 1/2.

First dorsal pore: 4/5.

Setae: Numerous per segment from ii: 24-32/12 and about 36/20, with slight mid ventral and mid dorsal gaps. No setae between male pores.

Nephropores: Not seen.

Clitellum: Annular over ½13,14-½17 but interrupted by ventral markings, furrows less distinct on 14/15 and 15/16; some setae retained.

Male pores: On 18 in pair of opposed raised porophores which are pert in equator.

Female pores: Paired anterior to mid-setal gap on 14.

Spermathecal pores: 7/8 and 8/9 only faintly marked in deep intersegmental furrows slightly wider apart than male pores.

Genital Markings: Faint paired discs within raised pads equatorial or presetal in 10 and 11 and sometimes 12 (occasionally one or both pads faint); paler patch ventrally in 15 and in 16, either containing a single midventral disc (sometimes these markings not visible); in anterior of 17 a pair of discs either closely paired or as wide as male pores in tumid area; small pair of discs seen in 19 near 18/19 just wider than male pores; in 20 and sometimes 21 mid-ventral tumescence containing closely paired discs (sometimes absent, sometimes appearing in 19 instead).

Septa: 5/6 weak, attaching to gizzard at its midriff; 6/7 slightly thickened at base of gizzard, 7/8-13/14 none especially thick, thereafter thin.

Dorsal blood vessel: Single, continues on pharynx.

Hearts: Commissurals 6-9, hearts large in 10-12; supraoesophageal vessels not seen.

Gizzard: Large and muscular in 5 but appearing displaced to 6, with wide anterior lip.

Calciferous glands or diverticula: Not seen but oesophageal dilations noted for 8-13 (rugose valves in 14-15?).

Intestine origin (caeca, typhlosole): 16 (acaecate, atyphlosolate).

Nephridia: Meronephric; pharyngeal tufted nephridia present in (at least) 4-5; mostly equatorial forests of meronephridia.

Testis/sperm funnels: Iridescent testis and funnels free in !0 and 11. Seminal vesicles racemose sacs in 9 and 12.

Ovaries: In 13 as large pair of palmate strands with numerous egg strings.

Prostates: Large racemose S-shaped glands extending over 2-3 segments and bisected by 18/19, with curved thin muscular duct.

Spermathecae: In 8 and 9 two pairs with flattened, sub-spherical ampullae tapering to short duct each bearing at the ectally a long digiform iridescent diverticulum.

Gut contents: Fine soil and grits.

Notes: Especially distinctive are genital markings in 10, 11 and 20 which, although varying between the specimens, are the most consistent locations. Other slight differences in the accounts are that Spencer (1900) records oesophageal swellings in 8-10 only, has the first dorsal pore in 5/6 (rather than 4/5) and describes the prostates as "bilobed" in 18. The coils of the tubuloracemose prostates may, at first glance, be mistaken as bilobed until they are teased out. Michaelsen noted Spencer's typographical errors: genital markings in "10, 11 and 12" (instead of 20) and gizzard in "3" (rather than 5) were corrected in his illustrations (Figs. 55-57). The location recorded by Spencer (1900) was Cooran and Gayndah, Queensland, the specimens reported here were also collected from near Gayndah.

Sims and Gerard (1985) describe a species introduced from Australia to Scotland which they call *S. minor*, however it varies from other descriptions in having anterior genital markings widely paired in 10 only. Superficially, their specimen resembles *S. celmisiae* from NSW, but this species has three pairs of spermathecae rather than two pairs and there are now many other similar species known.

In glasshouse trials (Blakemore, 1994, 1997), this species had a negative effect on plant growth and, of twelve specimens added to two large soil cores, only three were recovered six months later.

Genera of ***Pheretima*** auct. *s. lato* (i.e., the "***Pheretimoids***")

Diagnosis: Megascolecidae with racemose prostates, meroic nephridia, perichaetine setae, and a single well developed gizzard occurring between septa 7/8-10/11, usually it is in 8 (except for the monotypic genus *Pleionogaster* that has intestinal gizzards too).

Notes: Small paired sacs of unknown function that resemble seminal vesicles are often present on posterior of septa 12/13 and 13/14; variously called "*ovisacs*", "*coelomic sacs*", "*pseudoseminal vesicles*" (Easton, 1979: 8), cf. dorsal intestinal or lymph glands.

Taxonomic Remarks: Taxa are collectively called **pheretimoids** - an informal name. Superficially, exotic pheretimoid species may be confused with perichaetine natives such as the Australasian *Diporochaeta*, *Perionychella* and *Anisochaeta* and the Indian *Megascolex* (syn. *Perichaeta*), *Lampito* and *Perionyx*. However, unlike the pheretimoids, species of these latter genera may have clitella extending beyond segments 14-16, often have wider ventral and dorsal gaps in the setal rings, and gizzards, if present, before 7/8. A further subgenus once thought to be similar to *Pheretima* was *Promegascolex* erected by Cognetti, 1922: 744 for his *Megascolex* (*Promegascolex*) *mekongianus* which was misdescribed and was found by Blakemore in Blakemore *et al.* (2007b) to be an *Amynthas* although previously thought closer to *Megascolex* (cf. Gates, 1934: 260; 1972: 148; Sims & Easton, 1972: 223).

Note on synonymy of *Perichaeta* Schmarda 1861 with '*Pericheta*' Rondani, 1859:

*Synonymic Perichaetidae Claus, 1880 for *Perichaeta leucocycla* Schmarda, 1861 that, although probably still an available name, should be avoided for nomenclatural stability. Homonymy of *Perichaeta* Schmarda 1861 with *Pericheta* Rondani, 1859 (Diptera) was due to confusion of an extra "*a*". Cf. Airey-Neave (ref.) and Sabrosky (1999) for Dipteran homonyms in which it is stated:

"Perichaeta. See Pericheta.
*Pericheta Rondani 1859: 152 (unjustified new name for **Policheta** Rondani). Type, Tachina unicolor Fallen 1820 (aut.) = Policheta unicolor (Fallén). Tachinidae.*
*Senior synonym (not the basis of a family-group name): **Policheta** Rondani 1856: 67. Type, Tachina unicolor Fallén 1820 (orig. des.) = Policheta unicolor (Fallén). Tachinidae.*
Perichaeta (error) Brauer & Bergensta mm 1889: 99 (31).
***Perichaetidae** Brauer & Bergensta mm 1889: 82, 99 (14, 31).*
Note. Herting (1984: 23) adopted Perichaeta on the ground that Policheta was the "misspelled homonym of Polychaeta Macquart 1851." The "homonym" was repeated in Herting & Dely-Draskovits (1993: 153). However, Policheta and Polychaeta are distinct names (Code, Art. 56b), not homonymous."

Although there may be rare reports since Michaelsen (1900: 212), as Sims & Easton (1972: 176) explain: "*Michaelsen made* Perichaeta *Schmarda, 1861 a junior syn. of*

Megascolex *which it has remained ever since and perhaps should continue to do so for reasons of nomenclatural stability, although non-occupied and still available*".

Distribution: The concept of a "Pheretima *group domain*" was pioneered by Michaelsen (Fig.) and refined by Easton (1979) with Japan, Korea and 'Manchuria' (NE China) as the northern boundary through China to the Chindwin-Irrawaddy axis of Myanmar and the Indo-Australasian Archipelago eastwards, now excluding the volcanic Comoros Islands north-west of Madagascar (where they were almost certainly introduced by man), but including New Caledonia and many southwestern Pacific island groups. The north-western boundary appears to be Mongolia and Tibet (Michaelsen, 1929), and the south-eastern limit is set by the Torres Straits (and Cape York?). Gates (1972: 13) believed the evolution of pheretimas was centred in south-east Asia, perhaps around what is now Thailand. Several species have had their distributions greatly extended, both within and outside the *Pheretima* domain (Fig.), mainly by human-mediated transportation, so that their precise origins are uncertain.

Notes: From Michaelsen's (1900) listing of 167 valid species, many previously in the genera *Megascolex* and/or *Perichaeta*, the systematics of *Pheretima* auct. became increasingly unwieldy and chaotic until the long overdue revisions by Sims & Easton (1972). These authors reallocated nearly 800 nominal species and subspecies in their nomenclator (i.e., including both valid and synonymous names) into 'convenient' species-groups within eight genera using computer-based phenetic analysis, and this scheme was slightly amended by Easton (1976; 1979; 1982). However no attempt was made to describe nor revise all taxa, and probably less than half the nominal species, i.e., ca. 400, could be regarded as valid (Sims, 1983: 468). Lee (1981) remarked that the resulting generic divisions of Sims & Easton (1972) often have overlapping geographical distributions and diagnostic characters (see Table of Characters below – Table 4). Lee (1981) also commented that recourse to computer analysis for systematic resolution requires careful weighting of characters otherwise the results "*can only lead to the substitution of a new kind of confusion for the old*". Naturally, any results from such analyses also depend on the quality of the data input.

A comprehensive checklist of taxa is available (Blakemore, 2004, 2005, 2007, 2008) with ~930 valid names and at least 500 synonyms listed (total >1,400 names).

The following Table, Keys to the Genera, and Distributions of *Pheretima*-group complex are updated from Sims & Easton (1972) and Easton (1979; 1982) with additional information and amendments from the author's studies and other resources.

Sims & Easton (1972: 211) defined *Amythas* with superficial male pores "*discharging directly onto the surface*", thus in the current account specimens having **non-superficial** male pores includes those with penes and/or with varying levels of copulatory pouches are excluded [cf. Gates' (1982: 52) incorrect attempt to classify male pores as "*non* invaginate"].

On this wider issue, that of the genera *Amynthas* and *Metaphire* possibly not being monophyletically sustainable, this was recognized early on by its authors. Sims & Easton (1972: 171, 214) realized the difficulty in placement of several component taxa when they established *Metaphire* mainly for taxonomic 'convenience' to provide "*smaller, more manageable groups*". However, its male pores in copulatory pouches are obviously a derivative from the superficial male pores as definitive of prior *Amynthas* thus its retention has phylogenetic merit. Compare this to Gates (1982: 52) who, despite accepting (on page 38) that invagination of genital pores is a secondary development, makes this false distinction in his male pore differentiation categories:

"*invaginate*" or "*superficial, i.e.,* ***non-invaginate***"

The key phrase is bolded because I wish to emphasize this important point to show how Gates, and those who blindly follow this reasoning, make their fundamental mistake. It makes little common sense nor phylogenetic sense (and also defies ICZN Code) to have "invaginate" male pores as the primary division when the opposite is the case: i.e., from Blakemore (2000) male pores are either "*superficial or* ***non-superficial***", just as setae are either lumbricine or non-lumbricine, nephridia are holoic or "non-holoic" and prostates are either tubular or "non-tubular" derivatives. This distinction is even more valid when the current 'default' genus is *Amynthas*. with superficial male pores rather than *Pheretima* or *Metaphire* that, by definition and original designation of type-species, both have non-superficial male pores.

Degree of development from the primitive superficial pores in species with non-superficial male pores is largely irrelevant for generic placement, except newly for *Duplodicodrilus* Blakemore, 2008.

Resolution of the slightly complicating issue of species having specimens with parthenogenetic degradation and its effect on male pore presence and form, is discussed by Gates (1972, 1982) and Blakemore (2002, 2003, 2008, 2010, etc.).

Here I must yet again re-iterate for the benefit of current and future workers who may have the misfortune to read and to try to comprehend retrogressive

publications such as by James *et al.* (2005) who, on page 1013 for instance, say:

"*Gates (1975, p. 7) wrote, ''Presence or absence of copulatory chambers is too vague. The really important character is whether the male pores are superficial or invaginate. In the latter case, whether in slight transverse slits or much deeper spaces still confined to the parietes or whether thick-walled copulatory chambers deeply penetrating into coelomic cavity (cf Gates 1972, p. 150)''* and "*We support following the suggestion of Gates (1975) to better characterize the status of various types of non-superficial male pores. For now we support restricting Metaphire to those species distinguishable from Pheretima only by the absence of nephridia from the spermathecal ducts (Sims and Easton 1972)*."

According to this view of James *et al.*, the type species of the genus *Metaphire* would not qualify for membership of the genus, clearly a ridiculous concept. What is important to realize is that Gates' (1972, 1975, 1982) publications are taxonomically wrong. They are wrong because for ca. 10 years he ignores the comprehensive revisions of the pheretimoids by Sims & Easton (1972) and Easton (1979) that restored and elevated genera, including *Amynthas* and *Metaphire*, whereas Gates (e.g. 1982) deliberately continues for another decade to incorrectly cite only the subordinate genus *Pheretima*. James *et al.* (2005) are themselves wrong as they fail to understand the fact that under rules of ICZN the genus is defined by the type-species and thus for *Amynthas* and *Metaphire* the male pores are superficial or non-superficial, respectively, as in their respective type-species. Also their statement is nonsensical as *Metaphire* IS differentiated from *Pheretima* as currently defined only by the absence of nephridia from the spermathecal ducts, regardless of the details of the non-superficial male pores (Sims & Easton, 1972; Easton, 1981; Blakemore, 2002, 2005, 2007, 2008, 2010, etc.). So it seems James *et al.* (2005) themselves continue to cause and perpetuate confusion for 33 years and, were their scheme to be followed, we would arrive at the ridiculous situation of having the type-species of Sims & Easton's genus *Metaphire* – i.e., *Metaphire javanica* (Kinberg, 1867) – ineligible for membership of its own genus!

Ignorance of James (2007: 130, 137) on the issue in pheretimoid placement is further demonstrated when he writes: "*Their sole distinction between* Pheretima s.s. *and* Metaphire *is the presence of micronephridia on the spermathecal ducts of the former, implying that the origin and form of the copulatory bursae in the two genera is the same*." What this actually implies lack of basic understanding of taxonomy whereby the genus is defined by the characteristics of the type-species, to reiterate very clearly and simply: *Metaphire* is for species with **NON-SUPERFICIAL** male pores as found in type *M. javanica* (and *M. californica*) whereas the non-superficial

male pores in *Pheretima* are deeper invaginations as in type *P. montana* Kinberg. Thus there is no implication that the form of the male pores is the same in the two genera. This obvious and logical fact has been repeated frequently, not least in the many earlier publications of the current author.

Table 4. *Pheretima*-group characteristics, including Philippine genera described by James, 2004a plus *Duplodicodrilus* Blakemore, 2008 and *Manus* Blakemore, 2010

Genus	Intestinal caeca (origin)	Male pore structure	Nephridia on spermathae	Other characters
Amynthas	Ca. 25-28	Superficial	No or Yes	Holandric or metandric
Archipheretima	Absent	Superficial	No	Clitellum 13-16,17,18
Begemius	25	Superficial	No	Crescentic marks around male pores; metandric
Dendropheretima	25 and simple pair	Superficial	No	Arboreal. Calciferous lamellae in 11-14; holandric. [Cf *Ephemitra* (= *Metapheretima*) or *Begemius*]
Duplodicodrilus	Ca. 27, manicate (always?)	Massive eversible intoromittant organs	No	Represents extreme form of male pores, probably derived from *Metaphire*-like progenitors
Isarogoscolex	From 29,30 two pairs	Superficial	No	Arboreal. Calciferous glands in 11-13. [Cf. *Pl. arboricola* (Rosa, 1890) from Myanmar]
Manus	Ca. 27	Non-superficial (pouched)	No	Secretory diverticulum to each copulatory pouch
Metapheretima	Absent	Superficial (on porophores) or pouched (with penes)	No	Crescentic markings usually around male pores
Metaphire	26-27	Non-superficial or pouched	No	Holandric, proandric or metandric
Pithemera	22-24	Superficial	No	
Pheretima	ca. 27	Pouched	Yes	
Planapheretima	Absent or from 26-27	Superficial or non-superficial and pouched	No	Arboreal. Body flattened with "creeping sole"; crescentic marks present (type) or absent.
Pleionogaster	Absent	Superficial	No	Gizzards 26-28,29
*Polypheretima**	Absent	Porophores or pouched (no penes)	No	Clitellum 14-16. No crescentic marks around male pores

*In *Polypheretima* the spermathecae may be multiple, i.e., polythecal as in some species of *Amynthas*, *Metapheretima*, and *Metaphire*, or aborted; when present, the diverticula are simple (cf. multilocular in *Archipheretima* and some *Metapheretima*). Cresentic marks around male pores (characteristic of *Begemius* and several species of other genera, e.g. *Metapheretima*, *Pleionogaster*, *Planapheretima*) are not found in *Polypheretima*.

Introductory Key to Pheretimoid Genera

1. Setae crowded ventrally in 'creeping sole', body flattened..... *Planapheretima*
   Setae not crowded ventrally, body cylindrical..... 2
2. Oesophageal gizzard vestigial, intestinal gizzards (in 26-28,29) ... *Pleionogaster*
   Oesophageal gizzard present, intestinal gizzards absent..... 3
3. Lateral intestinal caeca absent (dorsolateral pouches may be found) 4
   Lateral intestinal caeca present..... 7
4. Oesophageal gizzard before 7/8....……..... *Lampito*, *Megascolex,* etc.
   Oesophageal gizzard after 7/8..... 5
5. Clitellum from 13; spermathecal diverticula multilocular ..... *Archipheretima**
   Clitellum from 14; spermathecae (if present) with simple or multilocular diverticula..... 6
6. Crescent markings typically associated with male pores..... *Metapheretima*
   Crescent markings absent; spermathecae (if present) with simple diverticula; clitellum annular restricted to 14-16……..... *Polypheretima*
7. Intestinal caeca originating in 25..... *Begemius*
   Intestinal caeca originating before or after 25..... 8
8. Intestinal caeca originating in or near 22..... *Pithemera*
   Intestinal caeca originating in or near 27..... 9
9. Male pores superficial discharging directly onto the surface..... *Amynthas*
   Male pores non-superficial within apertures of copulatory pouches... 10
10. Spermathecal ducts free of nephridia..... 11
    Nephridia on spermathecal ducts..... *Pheretima* s.str.
11. Large, eversible and doubled intromittant organs present …… *Duplodicodrilus*
    Male pores not not as developed ……12
12. Tubular secretory diverticulum to each copularory pouch …… *Manus*
    Tubular secretory diverticula absent ……..… *Metaphire*

* *Archipheretima* is from Borneo and the Philippines, no species are known peregrines.

Notes: After Sims & Easton (1972: 211) only superficial male pores qualify for *Amynthas* (i.e., in specimens with penes and/or copulatory pouches they are obviously and phylogenetically 'non-superficial'). [Cf. Gates' (1982: 52) incorrect attempt to classify male pores as "***non*** *invaginate*"]. Specimen fixation may cause copulatory pouches to evert, or superficial pores to slightly invaginate; also these structures are under-developed in immatures (e.g. Easton, 1979: fig. 3) or absent in parthenogenetic

morphs. Thus, specimens of *Amynthas* may be confused with *Metaphire* and *vice versa* and by default Sims & Easton (1972: 268) assumed no pouches (i.e., *Amynthas*), whereas *Metaphire* species were re-assigned to *Pheretima* s. str. whenever further study proved nephridia on spermathecal ducts (Sims & Easton, 1972: 211, 218, 221, 268). Suction applied with a wide nozzel syringe may be used to determine presence of a penis within the male pore in fresh specimens. Or slight pressure can be applied by hand in the field or lab to living specimens. Parthenogenetic athecal *Pheretima* or *Metaphire* morphs are difficult to differentiate, while those lacking male pores may be confused with *Amynthas*. Such specimens need to be reconciled with their amphimictic and ancestral populations. Sims & Easton (1972) list as *incertae sedis* several nominal taxa in which these organs were absent or inadequately described, some of these names have since been synonymized when found to comply with prior species. Easton (1979) refined genera and recombined *Ephemitra* in *Metapheretima* that is differentiated from *Polypheretima* in generic definitions below.

Origins and Distributions of Pheretimoid Genera

[After Sims & Easton (1972); Easton (1979, 1982); Blakemore (2007, 2008, 2010)]. **Note**: *Amynthas* is sometimes dated as Kinberg (1866) but Michaelsen (1900: 234) has "Kinberg, 1867 (66?)" and Sims & Easton (1972) have "Kinberg, 1867".

Amynthas Kinberg, 1867 - Oriental region, ?Australasian region, also many islands in Oceania, and introduced globally. A dozen or so species are peregrine of which six had previously been recorded from Australia (Easton, 1982).

Archipheretima Michaelsen, 1928 – Philippines and Borneo. Type-species *Megascolex iris* Michaelsen, 1892. The New Guinea species *P. tumulifaciens* (Lee, 1967), which was provisionally incuded in *Archipheretima* by Sims & Easton (1972), was transferred to *Metapheretima* as a junior synonym of *M. jocchana* (Cognetti, 1911) by Easton (1979: 22, 113). James (pers. comm.) redefines *Archipheretima* with dorsolateral caeca and now confined to Philippines (but cf. *Metapheretima*).

Begemius Easton, 1982 - endemic in Papua New Guinea and spread to northern Queensland (see genus definition below).

Dendropheretima James, 2004a with type *D. banahawensis*. Philippines, two species. [Cf. ?*Pithemera vitiensis* (Beddard, 1892: 131) and *Pithemera sempoensis* (Kobayashi, 1938: 149) that have caeca near 24].

Duplodicodrilus Blakemore, 2008 with type *Duplodicodrilus schmardae schmardae* (Horst, 1883) - Oriental from China and Japan also transported (e.g. to USA).

Ephemitra Sims & Easton, 1972 with type *Pheretima sentanensis* Cognetti, 1911 from West Papua – after Easton (1979) now absorbed in *Metapheretima*.

Isarogoscolex James, 2004a with type *I. abiadai*. Philippines, two species. [Cf. *Planapheretima arboricola* (Rosa, 1890) from Myanmar].

Manus Blakemore, 2010, monotypic for Japanese *Ma. koellikeri* (Michaelsen, 1928).

Metapheretima Michaelsen, 1928 - New Guinea, New Britain, Lombok, also Carolines, Solomon Islands and Vanuatu. Type-species *Perichaeta neoguinensis* Michaelsen, 1892. Following Easton (1979: 10), *Ephemitra* is now included.

Metaphire Sims & Easton, 1972 - Oriental region from Japan to Indo-Australian archipelago and Oceania. About eight species are peregrine.

Pheretima Kinberg, 1867, with two sub-genera:

Pheretima (*Pheretima*) Kinberg, 1867 – Indonesia and Malaysia to New Guinea; with a few peregrine species (e.g. *P. darnleiensis*, *P. montana*, *P. unicystis*).

Pheretima (*Parapheretima*) Cognetti, 1912 – Borneo, New Guinea. [*P. koellikerii* from Japan was transferred to *Metaphire* by Blakemore (2005, 2007) removing Japan from the generic range; this species was subsequently made type of the new genus *Manus* Blakemore, 2010].

Pithemera Sims & Easton, 1972 – Philippines and Taiwan (endemic?), Solomon Islands, New Britain, Fiji, Samoa, Vanuatu and one species perhaps endemic to Korea (overlooked in distribution of Sims & Easton, 1972). Only the type, *Pithemera bicincta* and its possible synonym, *Pi. violacea*, are peregrine outside this region.

Planapheretima Michaelsen, 1934 - China, Myanmar, Sumatra, Borneo, Celebes, New Guinea, Vanuatu. Type-species: *Pheretima moultoni* Michaelsen, 1913. Species not known outside regions of endemicity – a report (Nguyen et al. 2014) of *Pl. arboricola* and Chinese species from Vietnam are possibly misidentifications.

Pleionogaster Michaelsen, 1892 - from Philippines (Manila, etc. on Luzon and Samir Isls.) and Moluccas, although Easton (1979: 116) and James (2004a: 308) argue that "*Ternate, Moluccas, Indonesia*" is actually Ternate, Luzon, Philippines. Monotypic for *Perichaeta horsti* Beddard, 1886 - a senior synonym of *Pleionogaster jagori* and *Pleionogaster samariensis* both by Michaelsen, 1892, *Pleionogaster ternatae* Michaelsen, 1896, *Pleionogaster sivickisi* Stephenson, 1933 and *Pleionogaster* sp. Gates, 1942 – according to Easton (1979: 114),

where the type-species was fixed as *Pleionogaster jagori* Michaelsen, 1892 with the genus name corrected as here. Michaelsen (1900: 210) had the genus name as "Plionogaster" (illegal emend.) and (Reynolds & Cook, 1976: 114) mistakenly asscribe *P. horsti* to "*Michaelsen, 1896*" rather than to Beddard, 1886. Primary types are in BMNH:1974.1.86-89. [Gates (1043) described a "*Plionogaster* sp.; while James (2005) questions the justification of synonymy of some species].

Polypheretima Michaelsen, 1934 - endemic region includes Vietnam, Malaysia, Indonesia and New Guinea [*Po. iizukai* from Japan is a misidentification – see Blakemore (2003), and this removes Japan from natural generic range]. Peregrine species are *Polypheretima brevis*, *Po. elongata*, *Po. pentacystis* and *Po. taprobanae*.

Peregrine *Pheretima s. lat.* include these species, at least:
Amynthas aeruginosus, *Amynthas alexandri* (including its synonym *P. lignicola*), *Metaphire anomala*, *Metaphire bahli*, *Pithemera bicincta*, *Metaphire californica*, *Amynthas corticis*, *Pheretima darnleiensis*, *Polypheretima elongata*, *Amynthas gracilis*, *Metaphire houlleti*, *Amynthas hupeiensis*, *Metaphire javanica*, *Amynthas minimus*, *Pheretima montana*, *Amynthas morrisi*, *Amynthas papulosus*, *Metaphire peguana*, *Amynthas pingi*, *Metaphire planata*, *Metaphire posthuma*, *Begemius queenslandicus*, *Amynthas robustus*, *Amynthas rodericensis*, *Amynthas taitensis*, *Polypheretima taprobanae*, and *Duplodicodrilus* (formerly *Metaphire*) *schmardae*.

Names of two classical taxa, *cingulata* and *indica*, have frequently been invalidly applied in the past but actually refer to *Megascolex cingulata* (Schmarda, 1861) and *A. corticis* (Kinberg,1867), respectively (cf. *P. darnleiensis*). Gates' *Pheretima arboricola* is a synomym of *Perionxy arboricola* Rosa, 1890, now in *Planapheretima* (see Easton, 1979: 76, fig. 27j, fig. 30a).

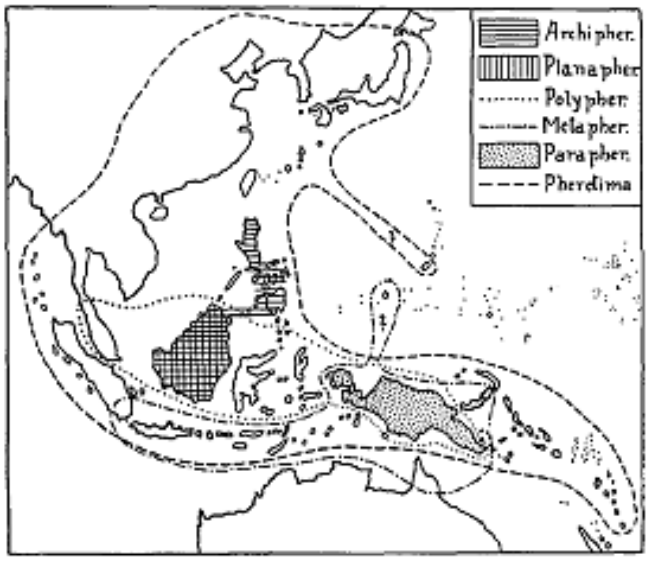
Pheretima americana bidentata Cernosvitov, 1942, cited by BIOSIS and Csuzdi's database (2008), is a *species et subspecies inquirendae* (see Blakemore, 2007).

As noted above, some earlier descriptions were rather unreliable and part of a taxonomist's job is to correct errors as soon as they are recognized, usually based on reinspection of types, e.g. Stephenson (1932) who kindly rechecked and corrected many errors in the original descriptions of mainly pheretimoid species described by Beddard (1900). From the numerous synonyms, or at least braces around his authorship, it seems

that the Rev. Hilderic Friend F.L.S. from Idle, Bradford (Ref) was similarly enthusiatic but, unfortunately, was rarely on-track – he described 120 "new" British oligochaeta that Cernosvitov (1942) says only about 13 can be recognized.

Gates too was a prolific worker producing copious papers but he often 'muddied the water', rarely had figures and when he did they were meaningless (eg. just a tiny part of the duct of a spermatheca), many of his types were destroyed and, moreover, although he was often rather disparaging about some others' work, he frequently reversed himself and failed to comply with priority. For example, Gates' (1982) obstinate refusal for 10 years to accept other than *Pheretima* for pheretimoid species, even after solid arguments and conventions were applied to justify this difficult task (as noted above) by Sims & Easton (1972) of which he was aware of in Gates (1972).

Where there is residual doubt, as with Beddard's species, it is often best to depend on interpretations of generally more reliable authors such as Michaelsen, Stephenson and Dr Ken Lee who often inspected types (where available) to resolve confusion. All this before the current objective solutions offered by DNA analysis and COI barcoding of primary and secondary types.



Geographical sketch: Distribution of the sub-genera of Pheretima.

Distribution of Pheretimoid genera (from Michaelsen, 1934: 17 *jcs.biologists.org/content/s2-77/305/1.full.pdf* Oligochaeta from Sarawak).

Notes on Spermathecae and Intestinal Caeca Pheretimoids are partly distinguished by their spermathecae (singular spermatheca) that serve to store partner's sperm, and caeca (singular, caecum) which are lateral pouches that, when present, occur on the intestine between segments 22 to 28 and possibly function for the maintenance of gut microfloral cultures and/or symbiotic protozoans (see references cited in Blakemore, 2003; 2005).

Gates (1958: 13) says "*One or two spermatheca may be added at either end of a series, in uniparental and biparental taxa, but in parthenogenetic lineages such mutational additions are much more rare than the subtractions*."

In the process of computerized revision of genera into more manageable groups, Sims & Easton (1972) gave some taxonomic importance to characters of the digestive system, even though it has long been recognized that these may be more adaptive than are the reproductive organs - the "*well known dependence of the conformation of the alimentary tract on food and environment*" (Stephenson, 1930: 720). Nevertheless, caeca have been accorded taxonomic significance: at the generic level by Sims & Easton (1972), whose redefinition of genera was based partly on the absence or, where present, the segmental origin of the caeca (see Table 1). Sims & Easton (1972: Fig. 1, 174, 182-183) recognized three caecal characteristics:

1. Presence of intestinal caeca (absent; present in 22; present in [or near] 27).
2. State of caeca in segment 27 (single, or multiple [= multi-caecate]).
3. Modification of caeca in segment 27 (simple, or complex [= multi-lobed]).

These caecal states condence to three usual forms:

1. Simple, i.e., single with smooth margins.
2. Complex, i.e., single lobed but with several small processes and/or incised margins (= serrate).
3. Multiple, i.e., composed of several digiform diverticula (= manicate or glove-like).

Different types of caeca are shown in Fig. 0.1 (below) albeit types 1A-1D may merely be age-related developments, and 1E-1F may be the same too. Interestingly, the genus *Planapheretima* Michaelsen, 1934 allows species with caeca manicate, simple, or absent; and Sims & Easton (1972: 222) allowed for *Pheretima (Parapheretima)* to have either simple, non-simple or multicaecate forms.

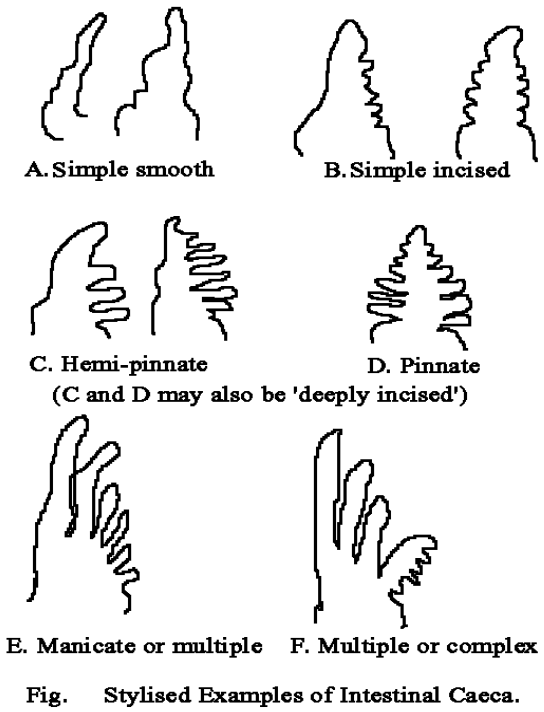

A. Simple smooth
B. Simple incised
C. Hemi-pinnate
D. Pinnate
(C and D may also be 'deeply incised')
E. Manicate or multiple
F. Multiple or complex
Fig. Stylised Examples of Intestinal Caeca.

Fig. 0.1 Examples of forms of Intestinal Caeca (original)

The difficulty of reliance on caeca is that some early reports do not distinguish between forms, and may even overlook the caeca completely, e.g. original descriptions of *Perichaeta iizukai* by Goto & Hatai, 1899 and in some synonyms of *Amynthas minimus* (see Sims & Easton, 1972: 224).

Gates (1939: 115) termed caeca as "*simple*" regardless of the depth of incisions on the dorsal and (or) ventral margins; and "*compound*" those that were "*glove-shaped*".

The present author (RJB) has found some specimens that seem to vary intraspecifically from deeply incised 'simple' to manicate (see *A. agrestis*).

Moreover, for lobate/serrate caeca, Sims & Easton (1972: 264) for *P. darnleiensis* (Fletcher, 1886/7) remarked that these "*cannot be regarded as taxonomic characters as they are more fully formed in the larger specimens and their development would appear to be correlated with growth*".

Key to Common Peregrine Perichaetine / Pheretimoid species

Notes: See also the Pheretimoid Genera Key above and curt Key to North American spp below. Immature specimens lacking genital markings (GM) are often difficult to determine. An annotated sketch of some common species after Easton (1982: fig. 4) - here. Non-pheretimoid megascolecid genera *Perionyx* and *Lampito* with peregrine species are described in earlier sections; native species endemic to some regions may also key out here so be cautious with identities.

1. Gizzard absent, or rudimentary in 5 or 6; nephrdia holoic .... *Perionyx excavatus**

   Gizzard(s) present; nephridia meroic (at least in forebody) 2

2. Oesophageal gizzards before 7/8; (acaecate) ……... *Lampito mauritii**

   Single oesophageal gizzard after 7/8 (pheretimoids) 3

3. Intestinal caeca present...…….....…….....…….... 4

   Intestinal caeca absent (*Polypheretima* or *Metapheretima*) ……. 34

4. Intestinal caeca simple (finger-like, conical or perhaps incised) ……...….. 5

   Intestinal caeca manicate (like fingers of a glove) ……..... 37

5. Male pores on 20 in copulatory pouches …… *Metaphire anomala*

   Male pores on 18, superficial or non-superficial (in copulatory pouches) .. 6

   Male pores absent (spermathecal pores present or absent) ……... 36

6. First spermathecal pores in furrow 4/5 (five thecal segments)…….....…. 7

   First spermathecal pores in or near furrow 5/6.....…. 9

   First spermathecal pores in or near furrow 6/7..... 20

   First spermathecal pores in furrow 7/8..... 29

   Spermathecal pores paired in furrow 8/9 ..... *Pheretima (Ph.) racemosa*

   If not dorsal, spermathecal pores absent or otherwise irregular ….... 35

7. Spermathecae one pair per segment ……... 8

   Spermathecal batteries (more than two per side) …… *Amynthas lavangguanus*

8. Small, male pores superficial, intestinal caeca near 22, clitellum short in 14-½16 .....

   Pithemera bicincta

Large, male pores in copulatory pouches, caeca near 27, clitellum longer 14-16 … *Pheretima darnleiensis* (part)

9. One or two thecal segments .....…… 10
   Three thecal segments .....…….…… 11
   Four thecal segments.....….. 13

10. One thecal segment …….....…..... 12
    Two thecal segments, pores in 5/6/7 ..... *Amynthas morrisi* species-group (cf. *A. loveridgei* and *A. incongruus* and its possibly synonym *A. lubricatus*).

11. Markings small near spermathecal and male pores; spermathecal diverticulum bulb ovoid …. *Amynthas gracilis* (cf. parthenogenetic morphs of *A. corticis*)
    Markings in transverse rows; diverticulum bulb elongate ... *Amynthas papulosus*
    Markings as series of papillae on 18 ……..... *Amynthas rechingeri*

12. Spermathecae with pores in 5/6 (no nephridia on ducts)... *Amynthas minimus* (part)
    Spermathecae with pores in anterior of 6 near 5/6 ..... *Amynthas papilio*
    Spermathecae with pores in 5/6 and nephridia on ducts ... *Pheretima urceolata*

13. Spermathecal diverticula long and zig-zag shape ..... *Metaphire bipora* / *Metaphire*? *malayana* (possibly in *Amynthas*), or if >2,000 mm and from Mekong River regions, *Amynthas mekongianus*
    Spermathecal diverticula not zig-zag arrangement …..……..… 14

14. Male pores superficial …….....…… 15
    Male pores in copulatory pouches ……..……...…. 19

15. Spermathecal pores ventrolateral; markings present or absent ……..…… 16
    Spermathecal pores dorsal, GMs in 18/19 and/or 17/18 ... *Amynthas rodericensis*

16. Genital markings present, often paired …….....…… 17
    Genital markings absent ……. *Amynthas alexandri* (cf. *A. carnosus/corticis*)

17. Large (ca. 450mm), large markings in 19-20, or 19-22 … *Amynthas juliani*
Size less than 350 mm long, markings differ ……..…….. 18

18. GM small, paired near male and/or spermathecal pores; prostate glands often aborted, spermathecal ducts smooth often infested with gregarine parasites….. *Amynthas corticis* (cf. *A. carnosus* and *A. exiguus* that have prostates).

GM fairly large, single midventral somewhere in 17-27 .... *Amynthas andersoni* species-complex in Myanmar, Yunnan and Thailand [cf. *A. feae* (Rosa, 1888) with a similar distribution range that may also be in this group].

19. GMs absent, nephridia on spermathecal ducts .....… *Ph. darnleiensis* (part)
GMs paired in 17 and 19, no nephridia on spermathecae ... *Metaphire posthuma*

20. Bithecal, pores between equator of 6 and 6/7 ..... *Amynthas glabrus*
Two or three thecal segments …….. 21

21. Spermathecal pores minute close to 6/7-7/8, in 7 and 8 …… *Metaphire planata*
Spermathecal pores intersegmental in 6/7/8 or 6/7/8/9 ……. 22

22. Two thecal segments 6/7/8 …. ?*Amynthas godeffroyi* (cf. ?*Metaphire sandviciensis*)
Three thecal segments in 6/7/8/9 23

23. Male pores non-superficial in copulatory pouches with large C-shaped openings; spermathecal pores *c.* 0.3-0.5 circumference apart ..... **Metaphire houlleti* (cf. *M. virgo*)

Male pores superficial or in copulatory pouches but without large C-shaped openings; spermathecal pores ventral, ca. 0.16-0.30 body circumference apart (sometimes wider and closer to 0.5 C) 24

24. Genital markings absent ……..…..….. *Amynthas asiaticus* (cf. ?*M. tschiliensis*)
Genital markings, often as small discs, present ……...……. 25

25. GMs widely paired but median to male pores in 17/18 and/or 18/19 26
GMs not paired in 17/18 and 18/19 ……..... 28

26. Male pores superficial; (septa 8/9/10 retained) ……..... *Amynthas hupeiensis*

Male pores non-superficial within copulatory pouches ……..… 27

27. Genital markings elliptical pads with central aperture ... *Metaphire peguana* (cf. *M. saigonensis* and sexthecal morphs of *M. posthuma*)

Genital markings invaginated, never superficial ..... *Metaphire bahli*

28. GMs absent or closely paired on some of 7,8-9 and 18, 19 .... *Amynthas carnosus* (more usually with four pairs of spermathecae in 5/6/7/8/9 cf. *A. corticis*)

GMs anteriomedian to male pores on 18 and near spermathecal pores ... *A. robustus* (part) or *A. triastriatus* (from China and Vietnam) cf. *A. tralfamadore*.

29. One thecal segment in 7/8 … *Amynthas zebrus* with superficial male pores, or, if male pores non-superficial and pouched, *Pheretima* spp-groups: *Pheretima montana* (if with penial sheath) */ Ph. sangirensis* (if without penial sheath)

Two thecal segments in 7/8/9 ……..…….…. 30

30. Male pores superficial (cf. ?*A. forbesi*) …….……..… 31

Male pores in copulatory pouches (cf. ?*A. forbesi*)…..……..… 32

31. Male pores ca. 0.2 circumference apart ….. *Amynthas aeruginosus* (cf. *A. taitensis* / *A. hendersonianus*)

Male pores ca. 0.3-0.5 C apart … *A. robustus* [part, cf. *A. aspergillum, A. masatakae* (from Japan/Korea and Taiwan)*, A. triastriatus*, *A. tralfamadore*].

32. Spermathecal & male pores ca. 0.3-0.5 circumference apart ... 33

Spermathecal & male pores ca. 0.2-0.3 apart ... *Metaphire javanica* (cf. *M. californica*!).

33. Spermathecal diverticula zig-zags but is shorter than ampulla .... *M. californica*

Spermathecal diverticula straight and longer than ampulla ... *M. ryunome* (cf. *A. masatakae, A. robustus*)

34. Spermathecal batteries dorsal in 5/6/78 ……..…. *Metapheretima carolinensis*
Spermathecal batteries ventral in 5/6 and/or 6/7 ……. *Polypheretima elongata*
Spermathecal pores paired in 7/8 only…… *Polypheretima taprobanae*

35. Intestinal caeca simple (male and spermathecal pores present or absent)…...… 36
Intestinal caeca manicate (male and spermathecal pores present or absent).. 37

36. Male pores present … *Amynthas minimus* (part) (cf. *A. glabrus*, *A. robustus*)
Male pores absent … *Amynthas illotus* species-group

37. Male pores present, spermathecal pores paired in 5/6/7/8(/9) 38
Male pores may be absent, spermathecal pores absent or some of 5/6-7/8 39

38. Male pores superficial; spermathecal pores 5/6/7/8/9; genital markings paired on 18 or, in Gates' (1939: 100) "B" specimens, unpaired median on 17 and 19 …. *Amynthas manicatus* (Gates, 1931) species-complex of 5 sub-species in Vietnam, Myanmar, Thailand, China (Yunnan), and Laos.
Male pores in copulatory pouches; spermathecal pores 5/6/7/8; markings none ..... *Metaphire birmanica* (Rosa, 1888: 164) from Myanmar, China (Yunnan), India (Himalayas) and (as '*Pheretima birmanica*') from the Punjab of Pakistan (Ref.), also Vietnam and Laos. [This species claimed to be a vermicomposter - Ref.]

39. Male pores large double eversible from copulatory pouches; spermathecal pores paired in 7/8/9 …….. *Duplodicodrilus schmardae* (cf. *M. musica*)
Male pores absent or either superficial or pouched; spermathecal pores, if present, **not** paired in 5/6/7/8(/9) **nor** just 7/8/9 …… *Metaphire hilgendorfi* / *Amynthas tokioensis* species-complex - here. [Four peregrine taxa: *Metaphire hilgendorfi* (Michaelsen, 1892), *Amynthas vittatus* (Goto & Hatai, 1898), *A. agrestis* (Goto & Hatai, 1899) and *A. levis* (Goto & Hatai, 1899) (= *A. tokioensis*) are reported from North America, all belong within the *M. hilgendorfi* / *A. tokioensis* group (cf. Blakemore, 2003 and descriptions below); see also *Metaphire soulensis*].

* Note: James *et al.* (2005) claimed seven '*new*' species of '*Amynthas*' from Taiwan. Of these, *Amynthas chaishanensis, A. hengchunensis, A. kaopingensis, A. ailiaoensis* and *A. huangi* should be in *Metaphire*. Furthermore, all seven names were synonymous: *A. huangi* to *M. houlleti* (Perrier, 1872), *A. chaishanensis* to *M. formosae* (Michaelsen, 1922), *A. kaopingensis* to *M. paiwanna*, *A. ailiaoensis* to *M. feijani*, and *A. monsoonus* to *A. tungpuensis*. This synonymy (from inspection of types) was by Tsai, C-F, Shen, H-P, Tsai, S-C and Hsieh, H-L (Tsai *et al.*, 2006, 2009) although *A. monsoonus* is also close to *A. carnosus* (Goto & Hatai, 1899) (pers. obs.), *M. hengchunensis* is in synonymy or at best a sub-species of *M. formosae* or *M. paiwanna* (according to Chang *et al.*, 2008), and *Amynthas nanrenensis* is another synonym of *A. corticis* spp-group (pers. obs.) Moreover, as Blakemore *et al.* (2006) said: "*James et al. (2005) have recognized seven new endemic* Amynthas *species from Taiwan and these authors claim first record of* Metaphire houlleti *plus new reports of* Amynthas incongruus *and* A. robustus*, although* M. houlleti *was published by Shen et al. (2005a),* A. incongruus *was recorded from Taiwan by Gates (1959) and* A. incongruus *and* A. robustus *were reported from Taipei by Tsai (1964), as shown by Shih et al. (1999) and Tsai et al. (2000a)*."

Shen *et al.* (2005a) had precipitously listed without much justification 59 species from Taiwan and claimed first records of *Metaphire houlleti* along with *Pontodrilus litoralis* and *Eiseniella tetraedra*, so, despite some apologistic denials from parts of Taiwan (e.g. by Wang & Shih, 2010; and Tsai, Shen *et al.* 2010), Blakemore *et al.*'s (2006) comments are entirely correct and valid. Moreover, Blakemore's prior MS from 2004 already listed all 57 Taiwanese taxa plus the first records of *Pontodrilus* and *Eiseniella* and would have had priority if not delayed to 2006 by *Pedobiologia* referees and/or editors. Attached are early drafts of the MSS by Blakemore *et al.* (2004a, b, c) that were rather too innocently sent for comment to Drs Huei-Ping Shen, Hsi-Te Shih and Chu-fa Tsai, amongst others, on 19th May, 2004, well before Dr Shen visited "*the National Museum of Natural Science to check the holotypes of James et al. (2005) on 6 November 2004*". Sightings of the MS is proven by its citatation as Blakemore or "*Blackmore et al.*" 2005/6 in "*Taiwania (in press)*" by (Tsai *et al.*, 2006).

But this all seems a bit petty, especially as James *et al.*'s (2005) record of *M. houlleti* was confused since they unintentionally also claimed it as *A. huangi* sp. nov!

In actuality, this and other errors in James *et al.* (2005) were already pointed out in a non-anonymous Referee's Peer Report dated 8th Jan, 2004 – as shown by the attached proof (RJB, 2004 Referee's Report) – and, although some of my advice was heeded, other errors persisted as deliberate or ignorant mistakes. In that referee report I at least managed to prevent publication of yet more synonyms of both *A. corticis* and *A. gracilis* – these were the manuscript names "*A. gajulanus*" and "*A. kaoshihfoensis*", respectively (see also Blakemore, 2010 Appendix). How could so-called "*expert*" authors not recognize these most obvious of common species? Hence considerable shame taints James *et al.*'s publication that, while merely satisfying egos and funding bodies, is mostly a distractional waste of time.

Then there is the débâcle of the *Pheretima urceolata* issue... Quoting from Blakemore's (2010: 21) "Saga of Herr Hilgendorf's worms" paper:

> "*Pheretima* (*Ph.*) *urceolata* (Horst, 1893: 322) [syns. *Ph. baweanensis* Michaelsen, 1924; ?*Ph.* (*Ph.*) *ditheca* Michaelsen, 1928; James', 2004 *P. baletei*, *P. bukidnonensis*, *P. heaneyi* and *P. kitangladensis*; *P. simsi* James & Hong, 2004; Hong & James', 2008 *P. abiadai* and *P. nagaensis*; and Hong & James', 2009 *P. batoensis*, *P. bicolensis*, *P. buhiensis*, *P. camarinensis*, *P. doriae*, *P. gorasi* and *P. viracensis* – these latter all **syns. novae**]."

Similar débâcles pertain for *Amynthas carnosus* in Korea and Taiwan, and *Pheretima darnleiensis* (Fletcher, 1886) in the Philippines (*vide infra*)...

Such lax work, along with all the misidentifications and misconceptions in Ishizuka (1999 and subsequently – but now invalidated by ICZN Art. 11.4) show how some 'quick' publications lack even most basic research and how poor taxonomy compounds the efforts of revisors to fix problems for many, many years following.

A century ago Horst (1899: 240) justly roasted Goto & Hatai for their poor work that has never been satisfactorily resolved, rather it has been compounded by later workers. It is quite a shameful disgrace and, as the Japanese put it, highly "*regrettable*" this attitude still persists today.

KEY to some early RECORDS of PHERETIMOIDS from NORTH AMERICA

[Updated from Gates (1958; 1982); SP – spermathecal pores, GM – genital markings].

1. Acaecal (i.e., intestinal caeca absent) 2
   Caecal (or caecate) 3

NO INTESTINAL CAECA

2. Male pores superficial, SP in 7/8 ..... *Polypheretima taprobanae**?
   Male pores somewhat invaginate, SP in 5/6-6/7 or absent ... *Po. elongata**

INTESTINAL CAECA SIMPLE (or slightly incised)

3. Intestinal caeca arising in 22 ..... *Pithemera bicincta*
   Intestinal caeca arising behind 22 (in 25-27) 4
4. Intestinal caeca simple 5
   Intestinal caeca manicate (glove-like) 14
5. Quadrithecal (i.e., two pairs of spermathecae) 6
   Not quadrithecal 8
6. Spermathecal pores at 5/6/7 ..... *Amynthas morrisi*
   Spermathecal pores at 7/8/9 7
7. Male pores superficial, genital markings present ..... *Amynthas robustus**
   Male pores invaginate, genital markings absent ..... *Metaphire californica*
8. Sexthecal (i.e., six pairs of spermathecae) 9
   Not sexthecal..... 12
9. Spermathecal pores at 5/6/7/8 ..... *P. hawayana* (= *A. gracilis*)*
   Spermathecal pores at or just behind 6/7/8/9 10
10. Male pores superficial, green colouration (coils and smell) ... *Amynthas hupeiensis**
    Male pores invaginate and in copulatory chambers 11
11. Penial body bilobed and with one genital marking .... *P. meridiana* (= *M. houlleti*)
    Penial body not bilobed and without genital markings ... *M. houlleti*
12. Spermathecal pores dorsal (i.e., demonstrably so and not just absent nor difficult to find - it is necessary to check thoroughly!) ..... *Amynthas rodericensis*
    Spermathecal pores ventral 13
13. Male pores invaginate, GMs paired in setal circles of 17 & 19 ... *Metaphire posthuma*
    Male pores superficial, GMs not so located .....*P. diffringens* (= *A. corticis*)

INTESTINAL CAECA MANICATE (or heavily incised)

14. Male pores in copulatory chambers ..... *Duplodicodrilus schmardae*
    Male pores not in coelomic copulatory chambers (or absent!) ... 15
15. GM, at least in the preclitellar region, SP (often) at 5/6/7/8 .... *Amynthas agrestis**
    GM present, spermathecal pores (often) at 6/7/8 16
16. GM small, closely crowded into median, presetal patches ... *Metaphire hilgendorfi**
    GM somewhat larger, not crowded into patches, usually near SP ..... *A. agrestis* or *A. levis* (= *A. tokioensis*)*

"*For explanation of the terminology, see Gates (1937: 342; 1939: 415)* [or Sims & Easton (1972)]... *Reproduction in those marked with an asterisk (*) is parthenogenetic; those marked (*?) may prove to be parthenogenetic. All organs that provide characters used in the key, except intestinal caeca, are liable to elimination after reproduction has become parthenogenetic. 'Advanced' morphs of polymorphic species cannot be keyed, but less advanced morphs probably could be keyed if data is available for some organs that are lacking in more advanced morphs*." Pheretimoids are not American natives – if specimens do not comply then try previous keys, that are more complete, progressively.

Comments on misidentification of *Pheretima browni* Stephenson, 1912 [skip].

Pheretima browni Stephenson, 1912: 273 was originally described for a "*large number of specimens, all in a bad state of preservation*" sent by Mr J. Coggin Brown from Tengyueh, Yunnan (China/Burma border region). The type was 4" long (100mm) with 108 segments and a dark brown colour. Male pores were large apertures not situated on papillae 0.3 circumference apart with 12 setae between. Spermathecal pores were in 7/8/9. Genital marks were absent. Setae numbered 23-44. The internal organization was as usual with holandric male organs (testes 10 &11; vesicles 11 & 12). Caeca simple from 26-23. Spermathecal ampulla ovoid, diverticulum coiled and dilated terminally, about as long as the ampulla. This description seems the same as for *Metaphire californica* (Kinberg, 1867), wherein this taxon likely belongs.

Gates (1932: 420, 435) examined three Indian Museum specimens labeled: "*Pheretima browni* Stephenson. Tengyueh, Yunnan. J. Coggin-Brown. Ex. 4891/7 Z.E.V. Types." They were much softened and decayed, one fell apart when he took it out of the jar, but he characterized the other (?two) specimens thus:

Male pores minute on disc-like area each with two rounded genital marking of about the same size as the male-pores discs, one presetal the other postsetal. Spermathecal pores in 5/6/7.

Although these were obviously different from the type, Gates (1932) claimed them synonymous (priority!) with his later description of *Pheretima hawayana lineata* Gates, 1926: 154, even though the characteristic preclitellar median markings were not found. Yet it seems to me that the great divergence of description indicates none of these were Stephenson's primary type, which is possibly in the British Museum (BMNH: 1925:5:12:30 or in Calcutta 4891) but was not inspected by Gates nor by Sims & Easton (1972). Whereas Gates' *P. hawayana lineata* is now considered the same as the common cosmopolitan *Amynthas morrisi* (Beddard, 1895), actually the part now *A. pallidus*.

Because of these supposed differences, Gates (1932: 420) described as *Pheretima molesta* "nom. nov." (?actually a ***sp. nov.***) specimens he had previously (Gates, 1931: 372) identified with Stephenson's *P. browni* as he clearly shows in Gates (1972: 174). But *P. molesta* is indistinguishable from *Metaphire californica* and thus joins *P. browni* in its synonymy as he again clearly shows in Gates (1972: 174). Chen (1933: 275) repeated Gates' mistakes. Moreover, Sims & Easton (1972: 238) erroneously footnoted that *Pheretima molesta* Gates, 1932 was a "nom. nov. pro *Pheretima browni* Gates, 1931: 372 (non Stephenson, 1912)" although I can find no

taxon "*Pheretima browni* Gates, 1931" despite being again cited as such by Reynolds & Cook (1976: 82, 139) and mistakenly by the Biodiversity Heritage Library catalogue (biodiversitylibrary.org/search?searchTerm=Pheretima+browni#/names, online 2014).

Thus the taxa are probably placeable in *Metaphire californica* or *A. morrisi* as above.

Genus ***Amynthas*** Kinberg, 1867

Amynthas Kinberg, 1867: 97 et *Amyntas* (laps.) pg. 101; Sims & Easton, 1972.

[Syns. *Amyntas* Kinberg, 1867: 101 (lapsus, nom. preocc. Woolaston, 1865 (Coleoptera) - see http://uio.mbl.edu/NomenclatorZoologicus/); *Nitocris* Kinberg, 1867: 102, nom preocc. Adams, 1854 (Mollusca); *Promegascolex* Cognetti, 1922 (see Blakemore *et al.*, 2007b); *Terrata* Thai, 1982. Non *Amythas* Benham, 1921 (Polychaeta : Ampharetidae) - a monotypic genus for Antarctic *Amythas membranifera* Benham, 1921 (sometimes misdated "*Benham, 1912*") a name that differs in having no "*n*" (Dr C. Glasby pers. comm. 26th March, 2006)].

Note: Some authors have date as Kinberg (1866), but Michaelsen (1900) has "*1867 (66?)*" and Sims & Easton (1972) also have "*1867*" and I have now confirmed this date.

Etymology: *AMYNTAΣ* is derived from Greek "*amyntor*" meaning "*defender*", an epithet that many Hellenistic kings and generals had.

Type-species: *Amyntas aeruginosus*, Kinberg, 1867 from Guam by monotypy fixed by Michaelsen (1899: 4).

Diagnosis: Setae perichaetine. Male pores superficial, never within copulatory pouches, on 18. Oesophageal gizzard in 8 and intestinal caeca usually originating in 27, rarely 26 (e.g. *A. lavangguanus*) or 25 (if 25 then holandric species only); intestinal gizzards absent. Spermathecae usually paired, rarely multiple or single. Nephridia meroic, usually absent from the spermathecal ducts (but not invariably). Hearts in most of 10-13 (some aborted).

Taxonomic Notes: Kinberg (1867) spelt the genus name *Amynthas* (p. 97) and *Amyntas* (p. 101); the former spelling has priority as its "*position precedence*" (ICZN, 1999: 69A.10) was confirmed by Sims & Easton (1972: 176) who noted that the first revisor – Vaillant (1889: 63), had cited it correctly as *Amynthas* – whereas the second name was preoccupied by a Coleopteran (sub-)genus. The type, *Amynthas aeruginosus* Kinberg, 1867, is particularly similar to *A. taitensis* (Grube, 1866) and, if they eventually prove to be synonymous, the latter would apparently have date priority.

Distribution: Oriental and Oceania regions, the natural distribution is unclear due to disproportionately high numbers of peregrine species.

Remarks: *Amynthas* comprises approximately 400 nominal species but possibly more than half are synonyms, with a dozen or so peregrine species. A premise in the extensive

revision by Sims & Easton (1972: 214; 268) was that species were assumed to belong to *Amynthas* rather than *Metaphire* (or *Pheretima* sensu stricto) unless re-examination of types shows them to have copulatory pouches (i.e. non-superficial male pores) and, secondarily for *Pheretima*, nephridia on the spermathecal ducts which, however, is also permissible in *Amynthas*; thus they initially attributed specimens described as lacking male pores to *Amynthas* by default.

Concerning male pores of *Amynthas/Metaphire*, their determination is straightforward when we have clear differences such as in *Metaphire schmardae* (that has copulatory pouches with huge eversible 'air-bags' with glands and penes and that is now combined as *Duplodicodrilus schmardae* – the type of the new genus), but there are sometimes borderline cases that may be decided either way. I think the answer is to simply ask: "*Are the male pores superficial*?" (the primitive/plesiomorphic state found in *Amynthas*). If not, then they are 'non-superficial' (apomorphic/derived as found in *Metaphire*) and, in further support for this reasoning, I quote Gates (1975: 7) on his opposite, confused and quite phylogenetically incorrect, view on this question:

> "*Presence or absence of copulatory chambers is too vague. The really important character is whether the male pores are superficial or invaginate. In the latter case, whether in slight transverse slits of much deeper spaces still confined to the parietes or whether thick-walled copulatory chambers deeply penetrating into coelomic cavity (cf Gates, 1972: 150).*"

[Cf. Gates' (1982: 52) attempt to classify male pores as invaginagte vs. "*non invaginate*" (sic) as opposed to my categories of "superficial" vs. "non-superficial"].

Complicating factors are that parthenogenetic morphs may lack male pores completely or, as stated by Easton (1982: 725), the techniques used to preserve specimens may cause copulatory pouches to evaginate making the male pores appear superficial, and in immatures the copulatory pouches may be undeveloped as Easton (1979) shows for *Polypheretima elongata* juveniles.

For *Amynthas* components of the *M. hilgendorfi / A. tokioensis* complex, see later section or jump there now from here.

Amynthas aeruginosus Kinberg, 1867

Fig. 2.3 Cf. *Amynthas aeruginosus* Kinberg, 1867, [possible sub-species *Amynthas aeruginosus rennellanus* (Gates, 1959) from Rennell] (a) ventral view (b) prostate (c)

spermathecae *in situ* (d) prostomium. After Blakemore (1997a).

Amyntas aeruginosus Kinberg, 1867: 101; Michaelsen, 1899: 4. [Type locality Guam, Marianas Islands. Types in Stockholm Museum: 154].

?Perichaeta upoluensis Beddard, 1887:174, Pl V, figs. 11-12. [Types in London].

Perichaeta oeriginosa (?lapsus pro *aeruginosa*) Beddard, 1891:278.

Pheretima aeruginosus: Michaelsen, 1900: 253 (syn. *oeriginosa* [sic]); Michaelsen, 1903: 94; Cognetti, 1913b: 37.

Amyntas aeruginosus (part.): Beddard, 1900a: 629 [syn. *musica, fasciata, longa, willeyi, ?operculata* Rosa (cf. *javanica*)]. [He says only size differentiates these names, l = 180-570 mm, but obviously *operculata* with its invaginate male pores does not belong (see Rosa, 1891: fig. 6)].

?Pheretima rennellana Gates, 1959: 11. [Type locality, Hutuna, Lake Te-Nggano, Rennell. Types in British Musem, 1957:11:5:25-26].

Amynthas aeruginosus (part): Sims & Easton, 1972: 211 (?syn. *upoluensis*, *rennellanus*); Lee, 1981: 542, figs. 2-6 (?syn. *upoluensis*); Blakemore, 1997b:22, fig. 2 (part = *A rennellanus*).

Taxonomic Note: Michaelsen (1903: 94) listed *P. aeruginosa* forma *musica* but this is now held separately in *Metaphire*. Easton (1984) removed *P. upoluensis* from *aeruginosus* and included both *upoluensis* and "*Pheretima recta* Ude, 1905: 432" [which is a lapsus for Ude's (1905: 431) account of *Perichaeta recta* Rosa, 1898: 284] in synonymy of *Amynthas taitensis* (Grube, 1866: 180) [non Grube, 1867 - see *Pheretima montana*], but he appears to have overlooked *Amynthas grubei* (Rosa, 1891: 395, fig. 4) that was placed in *taitensis* by both Michaelsen (1900: 308) and Lee (1981: 548). Another similar Pacific species is *Amynthas esafatae* (Beddard, 1899:187) (cf. *A. robustus*). Both *taitensis* and *esafatae* are briefly diagnosed below.

(The following account is compiled from references in the synonymy, plus inspection of British Museum syntypes and new material of *rennellana* - see Blakemore, 1997).

Diagnosis: *Amynthas* with two pairs of spermathecal pores ca. 0.2 body circumference apart in furrows 7/8/9. Male pores paired superficial ca. 0.2 circumference apart on 18. Genital markings variable small, (midventral in anterior) paired near male pores. Intestinal caeca simple originating in 27.

Distributions: Pacific Isles: *aeruginosus* – Marianas Island Guam, Vanuatu, West New Guinea (Majalibit Bay, Waigeu - Cognetti, 1913) and listed from Java (Buitenzorg,

Tjibodas) and Sunda, Engano by Michaelsen (1903: 94); *upoluensis* – Samoa, Vanuatu, Solomons, Cook Islands, Fiji, Marshall Islands; *rennellanus* – Rennell Island, Solomons; *esafatae* – Vanuatu, Solomons, Cook Islands, Fiji, Samoa, Marianas, Carolines, Marquesas, *taitensis* (inc. *grubei*, ?*upoluensis* and *recta*) – Taihti, Vanuatu, New Guinea, Cook Islands, Samoa, Tonga, Marquesas, New Caledonia (Michaelsen, 1900; Lee, 1981; cf. Easton, 1984). There is an unconfirmed report of *A. aeruginosus* from Brazil (G. Brown pers. comm. Dec. 2006), it seems more likely to be a misidentification as do the numerous reports from South Africa, e.g. Dlamini (2002) reported it from the Eshowe and Nxele (2012) has it from Queen Elizabeth Park, Pietermaritzburg, South Africa (from her description, it is indistinguishable from *Metaphire californica* or possibly a part of the *Amynthas robustus*-group of confused species lacking GMs).

Locality: Rennell Island, Solomons (Blakemore, 1994).

Behaviour: ?

Length: 55-113 mm (Lee, 117-132), body cylindrical.

Width: 4-5 mm (Lee, 4.5-6.5).

Segments: 84-117 (Lee, 118-128).

Colour: Brown with green-blue iridescence.

Prostomium: Epilobous.

First dorsal pore: 11/12 (or 12/13/14?).

Setae: Numerous, ca. 40-60 per segment; enlarged setae in anterior to segment 10.

Nephropores: Not found.

Clitellum: Annular in 14-16, setae occluded.

Male pores: 0.16-0.22 circumference apart on low porophores on 18.

Female pores: Single on 14.

Spermathecal pores: Two pairs in 7/8/9 0.2 circumference apart.

Genital markings: Variable (?single mid-ventral discs in some or all of 6-10); near male pores unpaired sometimes doubled median papillae pre-setally on some or all of 17-23, paired papillae pre- and post-setally 18 slightly median to the male pores and other pairs in line with them in 17/18, 18/19 and 19/20. Small transverse slit posterior to each porophore may be seen as a translucent area.

Septa: 4/5-7/8 and 10/11-12/13 slightly thickened, 8/9-9/10 aborted.

Dorsal blood vessel: Single.

Hearts: Last pair in 13.

Gizzard: Between septa 7/8 and 9/10.

Calciferous glands: Oesophagus pouches absent.

Intestine origin (caeca, typhlosole): In 15; simple, laterally paired caeca 27-19,18; (typhlosole?).

Nephridia: Meroic, tubules absent from spermathecal ducts.

Male organs: Testes/funnels in testis sacs in 10 and 11; small seminal vesicles in 11 and 12; coelomic pouches paired on septa 12/13 and 13/14.

Ovaries: Paired in 13.

Prostates: Large, racemose extending from 16,17-19,20, duct short and muscular to male pores. Copulatory pouches absent.

Spermathecae: In 8 and 9, with narrow duct about as long as the ampulla, diverticulum from ental half of duct has slender stalk and small simple seminal chamber. Spermathecal ducts free of nephridia.

Gut contents: ?

Remarks: The *Amynthas aeruginosus*-group of Sims & Easton (1972) has about 69 nominal taxa (including Easton's, 1979: 119 transfer of *P. petahana* Michaelsen, 1934). Work is still required to fully resolve the taxonomic relationships of this species-group for which *taitensis* has priority, especially since the distributions of genital markings of the components appear to overlap. Kinberg (1867) has tubercula in the anterior in 6-8, his brief orginal description:

> "*A. aeruginosus n. Lobus cephalicus fere obsoletus; cingulum segmentorum 13 et 14 breve; tubercula ventralia 4 inter segmenta 6, 7 et 8, setae anteriores et mediae 40-42:nae, posteriores 60:nae; segmenta 100; longitudo 90-100 m.m. Guam, sub lapidibus prope rivulum.*"

The description of *A. aeruginosus* above is compiled from those in its synonymy, excluding some characters referring to *A. upoluensis* which is currently in synonymy of *A. taitensis* (Grube, 1866) (see below). Sims & Easton (1972: 212) examined types and type material of both *A. upoluensis* and *A. rennellanus*, and concluded that *A. aeruginosus* is a variable species so they provisionally included both other taxa (but did not make a link with the prior *A. taitensis* nor A. *esafatae*). Nevertheless, they believed this grouping might eventually prove polytypic causing *A. upoluensis* and A. r*ennellanus* to be reinstated (as possible subspecies of *A. aeruginosus*). In earlier studies, *Amynthas upoluensis* had been separated from *A. aeruginosus* because it has mid-ventral genital markings in 9 or 10, 16-20 plus paired markings on either side of the male pores (i.e., similar to those of *A. aeruginosus* and *A. rennallanus*). *A. renellanus*

apparently differed from *A. upoluensis* (and *A. aeruginosus* and *A. esafatae*) by lack of thickening of septa 10/11/12 (see Blakemore, 1997c). Finally, *A. esafatae* (Beddard, 1899) which had similar spermathecae but without the narrow diverticular stalk and was at one time placed by Michaelsen (1913) in synonymy of *taitensis* (Grube, 1866) along with *upoluensis*, was differentiated from *A. renellanus* on its lack of midventral markings. Lee (1981:542) included specimes of '*upoluensis*' from Vanuatu in *A. aeruginosus*, but maintained *A. esafatae* and *A. taitensis* separately. Easton (1984:118) placed *upoluensis* and *recta* in synonymy of *Amynthas taitensis*, but appears to have overlooked *A. esafatae*. The following short descriptions of *A. taitensis* (including *grubei*, *upoluensis* and ?*recta*) and of *A. esafatae* are taken from Michaelsen (1900:265, 298, 308, 310) and Lee (1981:542, 545, 548):-

Amynthas taitensis (Grube, 1866: 180). [Type locality Tahiti. Types in Hamburg Museum, 8068] (syns. ?*recta*. *grubei*, *upoluensis*) as redescribed by Michaelsen (1900: 308; 1913: 267, fig. 6), and Kobayashi (1941: 394: fig 2). [See *Perichaeta Grubei* Rosa, 1891: 384, fig. 4 from Tahiti]. Length 70-166mm. Diameter ca. 5mm. Segments 95-120. Colour grey-brown. First dorsal pore 10/11/12(/13?). Setae regularly spaced, up to 60 per segment. Clitellum complete 14-15,16. Spermathecal pores paired in 7/8/9 ca. 0.2C in line with male pores. Male pores superficial paired on 18 in line with 7th or 8th (or 9th) setae (ca. 0.16C circumference). Four small genital markings in transverse row postsetally on 18 and 19, the two median markings slightly larger than the two lateral ones, additional markings near male pores and unpaired mid-ventral on 9,10, 16,17-20,21,22. Spermathecae in 8 and 9 saccular ampulla with long fiverticulum. Caeca simple from ca. 27. From, Taihti, Vanuatu, New Guinea, Cook Islands, Samoa, Tonga, Marquesas, New Caledonia; Kobayashi (1940) lists it from "*Hermit Island, New Hebrides Tonga Island, Marshall Islands – Jaluit, Society Islands – Tahiti, Loyalty Island Banks Islands, Samoa Islands, St. Mathias Island, Squally Island, Figi Islands, Paumotu Islands, Steward Island, Cook Islands, Caroline Islands – Ponape and Truk, Marianna Islands – Saipan and Papan*"; Easton (1984) lists it from Fiji, Tonga, Samoa and Niue as a new record.

Amynthas esafatae (Beddard, 1899: 187). [Type locality Efate Island, Vanuatu. Types?]. Length 75-115mm. Diameter 4mm. Segments 105-135. Colour purplish. Setae perichaetine, 56-78. Clitellum 14-16. Spermathecal pores slit-like paired in 7/8/9 in line with male pores. Male pores superficial, widely paired in line with 5th setae on 18. Genital markings paired in 9 and 10, and on 17-19 median, wider in 17/18 (and/or 18/19,

19/20), also two lateral and one median to the male pores. Holandric. Caeca pair in 27. From Vanuatu, Solomons, Cook Islands, Fiji, Samoa, Marianas, Carolines, Marquesas (see Gates, 1937: 318), i.e., widespread on tropical Pacific islands (by drifting or transportation?).

Amynthas alexandri alexandri Beddard, 1901

Fig. 2.3.3 *Amynthas alexandri* Beddard, 1901 (after his figs. 1-3); Fig. A2 from Thailand ex Pattna thesis (2008: 122).

Amyntas alexandri Beddard, 1901: 999, figs. 1-3. [From Kew in soil from the neighborhood of Calcutta type-locality (under ICZN, 1999: Art. 76.1.1). Holotype in British Museum, 1904:10:5:757]. [Often misdated "*1900*"].

Pheretima lignicola Stephenson, 1914: 399, fig. 17. [Type locality Dibrugarh, Assam. Types in Indian Museum].

[*Pheretima suctoria* Michaelsen, 1907 (part); Stephenson, 1923: 311. Excluding Andaman types with genital markings, i.e., this name not in synonymy].

Pheretima alexandri: Stephenson, 1923: 291; Gates, 1930: 314 (?syn. *lignicola*); Gates, 1931: 363 (syn. *lignicola,* ?*suctoria mullani*); Gates, 1972: 155 [syn. *lignicola*, *suctoria* (part)].

?*Pheretima suctoria mullani* Stephenson, 1924: 340. [From India. Types?].

Pheretima sp. Gates, 1972: 157. [From Thailand, possible biparental morph].

Amynthas alexandri alexandri: Sims & Easton, 1972: 234 (*diffringens* group).

Note: The other subspecies is ***A. alexandri gracilior*** (Gates, 1931: 371) from Myanmar that differs by having >14 setae between spermathecal and male pores (this taxa apparently overlooked or omitted by Gates, 1972; possibly because it is synonymous).

Diagnosis: *Amynthas* with four pairs of spermathecal pores ca. 0.3 body circumference apart in furrows 5/6/7/8/9. Male pores paired superficial on 18 (or absent). Genital markings none (cf. *A. corticis*) (or present in the male porophore). Intestinal caeca simple originating in 27. Spermathecal diverticula zig-zag.

Distribution: England (Kew Gardens ex Calcutta), Myanmar, Thailand (Bangkok, Chiang Mai, Chiang Rai, etc.), India: Andaman Islands, Mombai, Jubbulpore, Calcutta and the Punjab all by introduction (Gates, 1972: 156), also Nagaland, India (Reddy,

1980), Bangladesh, and Pakistan (Ref. as a '*new record*' from the Punjab as '*Pheretima lignicola*').

Behaviour: Although the name "*lignicola*" implies it feeds on (decayed) wood, it is described as "*geophagous*" in a note by Reddy (1980) about its seasonal mass migration and mortality down slopes in the early mornings in tropical, monsoonal India.

Length: 105-290 mm.

Width: 4-9 mm.

Segments: 90-141.

Colour: Pink to deep red-brown.

Prostomium: Rudimentary.

First dorsal pore: 12/13.

Setae: Numerous, ca. 50-90 per segment; enlarged setae in anterior in segments 2-9.

Nephropores: Not found.

Clitellum: Annular in 14-16, setae occluded.

Male pores: On low porophores on 18 often between arms of U-shaped ridges that open mesially (that is the ridges are above and below the pores and on the outside). About a dozen setae between pores. Sometimes lacking male pores (parthenogenetic morphs).

Female pores: Single on 14.

Spermathecal pores: Four pairs in 5/6/7/8/9 0.3 circumference apart (not so dorsal as in *A. trinitatis*).

Genital markings: None, but ridges around male pores are perhaps rudimentary marks (see remarks below).

Septa: 5/6,6/7/8 much thickened, and 10/11-11/12 slightly thickened, 8/9, 9/10 aborted.

Dorsal blood vessel: Single.

Hearts: 8-13, lateroesophageal in 11-13.

Gizzard: Between septa 7/8 and 9/10.

Calciferous glands: Oesophagus pouches absent.

Intestine origin (caeca, typhlosole): In 15; simple, laterally paired caeca 27-20; typhlosole present.

Nephridia: Meroic, tubules absent from spermathecal ducts.

Male organs: Testes/funnels in sacs in 10 and 11; large seminal vesicles in 11 and 12.

Ovaries: Paired in 13.

Prostates: Large, racemose extending from 16-22, duct muscular and looped.

Spermathecae: Smallish in 6-9, with long wide duct to small bulb-like ampulla and

slender diverticulum that exceeds the ampulla for length and a once-looped wider portion entally in type, or diverticulum with several zig-zag loops.

Gut contents: ?

Remarks: Beddard (1901) thought his species close to both *A. heterochaetus* (= *A. corticis*) and *A. trinitatis* differing mainly on its longer spermathecal ducts, and longer diverticula that exceed the ampullae. There is little, apart from lack of genital markings, to morphologically separate this taxon from *A. corticis*. While Beddard surmised it possibly Malayan, Gates believed this species, which has parthenogenetic morphs lacking male pores, originated in Thailand where a biparental morph was found. Before this species' account, Gates (1972: 154) provided a key to anatomically degraded parthenogenetic morphs, and accompanying this species' account (1972: 156) he gave examples of the kinds of degradation that are possible, while on the next page he described a "*Pheretima* sp." specimen that was possibly of a biparental population from Thailand that had small genital markings in the male pores.

Cast production is studies here (Ref.1) and population dynamics over 2 yrs in cultivated and pasture soils of the Kumaun Himalayas here (Ref.2, Ref.3).

This species was found in compost at Indore MP, the site of Sir Alfred Howard's organic farming research station, along with *Lennogaster pusillus*, *Metaphire houlleti* and *Eudrilus eugeniae* (RJB pers. obs. 20th March, 2016) (Ref.).

Amynthas andersoni (Michaelsen, 1907) species-group (Gates, 1972: 158)

Pheretima andersoni Michaelsen, 1907b: 167; fig. 13. [Type locality Amhurst, Burma. Types in Indian Museum].

Pheretima nemoralis Gates, 1932: 531. [From Heimza Basin. Omitted by Reynolds & Cook, 1976].

Amynthas andersoni: Sims & Easton, 1972: 234 [*diffringens* (= *corticis*) group].

Diagnosis: *Amynthas* with four pairs of spermathecal pores ca. 0.4 body circumference apart in furrows 5/6/7/8/9. Male pores paired superficial on 18 each in a distinctly delimited equatorial porophore. Genital markings postclitellar, large in some of 18-27.

Distribution: Myanmar to Yunnan, China; and into Thailand, Vietnam, and Laos (e.g. Thai & Samphon, 1989).

Behaviour: ?

Length: 190-260 mm.

Width: 6-11 mm.

Segments: 120-134.

Colour: Darker anteriorly.

Prostomium: Open epilobous.

First dorsal pore: 12/13.

Setae: 20-120 (mostly small and closely spaced).

Nephropores: ?

Clitellum: Annular mostly in 14-16 or just extending further.

Male pores: On 18 on large porophores that are each 3-6 setal intervals wide.

Female pores: On 14.

Spermathecal pores: Ca. 0.4 body circumference apart in furrows 5/6/7/8/9.

Genital markings: Unpaired and median transversely places across one or more of 18/19-26/27 consecutively.

Septa: 6/7/8 and 10/11-12/13 thickened, 8/9/10 aborted.

Dorsal blood vessel: ?

Hearts: 10,11-13.

Gizzard: in 8-9.

Calciferous glands: None.

Intestine origin (caeca, typhlosole): Caeca simple from 27-18.

Nephridia: Meroic.

Male organs: Testes/funnels holandric; large seminal vesicles in 11 and larger in 12.

Ovaries: In 13.

Prostates: Large, racemose, muscular U-shaped duct to superficial male pores.

Spermathecae: In 6-9, ampulla with narrowing duct and tubular diverticulum that is variously coiled or looped sometimes in a more or less regular zig-zag.

Gut contents: ?

Remarks: Species in the *andersoni* group keyed in Gates (1972: 158-166) and mainly differing in arrangement of genital markings, e.g. having markings paired or in three longitudinal ranks, are:

Pheretima analecta Gates, 1932: 501.

Pheretima analecta promota Gates, 1933: 494 (syn. *pannosa* Gates, 1936: 441).

Pheretima velata Gates, 1930: 321 (syn. *clavata* Gates, 1932: 541).

Pheretima compta Gates, 1932: 511.

Pheretima longicauliculata Gates, 1931: 395).

Pheretima labosa Gates, 1932: 543.

Pheretima sonella Gates, 1936: 458.

Pheretima luxa Gates, 1936: 427.

Pheretima andersoni choprai Gates, 1929: 233.

A more recent species from Vietnam is ***Amynthas andersoni doettrani*** Blakemore, 2006 a replacement name for the preoccupied secondary homonym *Pheretima andersoni minima* Do and Tran, 1995 (non *Perichaeta minima* Horst, 1893 = *Amynthas minumus*).

Cf. the mountain dwelling *Amynthas feae* (Rosa, 1888) that has a similar distribution and may also be in the *A. andersoni* group according to Gates (1972: 186); it differs primarily in its lack of genital markings.

Amynthas asiaticus Michaelsen, 1900

Amyntas asiaticus Michaelsen, 1900a: 13. [Type locality Tien-Tsin, China on Tibet borders. Types in Moscow Museum but Rego No.s not known].

Pheretima asiatica : Michaelsen, 1900: 527 (almost as an addendum); Michaelsen, 1903: 11 and 1903: 94 gives more localities in Tibet, some at 11,600-13,000' = ~4,000m (headwaters of the Mekong); Gates, 1939: 494 (syns. ?*tibetana* Michaelsen, 1931: 13, ?*guillelmi*); 1958: 28 [?syns. *tschiliensis* (priority!), *praepinguis*].

Amynthas asiaticus: Sims & Easton, 1972: 236 (*sieboldi* group); Blakemore, 2005; 2007.

Notes: Gates (1958: 28) thought it a possible synonym of *P. tschiliensis* Michaelsen, 1928 (priority!) – see separate description under ***Metaphire tschiliensis*** below.

Diagnosis: *Amynthas* with three pairs of spermathecal pores ca. 0.3 body circumference apart in furrows 6/7/8/9. Male pores paired superficial on 18. Genital markings none. Intestinal caeca simple originating in or near 27 with a few small wart-like outgrowths at the base.

Distribution: China, Tibet, with unconfirmed reports from Taiwan (Kuo, 1987 cf. Shih *et al*., 1999: 435), and in a study of vermicomposting in Philippines, a claim "*Only one species of earthworm,* Pheretima asiatica*, is used*" by DeLeon (1982); Wong & Griffiths (1991) in Hong Kong also claim its vermicomposting of pig manure.

Behaviour: It occurs at high altitude (but is claimed in tropical vermiculture by some).

Length: 120-145 mm.

Width: 6 mm.

Segments: 90-94.

Colour: grey (Cf. unconfirmed Taiwan report of *Ph. asiatica* being red).

Prostomium: ?

First dorsal pore: 12/13.

Setae: Numerous, ca. 44-66 per segment; enlarged setae in anterior in segments 2,3-8,9.

Nephropores: Not found.

Clitellum: Annular in 14-16, setae occluded.

Male pores: On large porophores on 18 ca. 0.3 circumference apart.

Female pores: On 14.

Spermathecal pores: Three pairs in 6/7/8/9 0.3 circumference apart.

Genital markings: None.

Septa: 5/6/7 and 10/11-13/14 thickened, 8/9/10 aborted.

Dorsal blood vessel: ?

Hearts: ?

Gizzard: Between septa 7/8 and 9/10.

Calciferous glands: ?

Intestine origin (caeca, typhlosole): Caeca long incised (from 27?).

Nephridia: Meroic.

Male organs: Testes/funnels holandric; large seminal vesicles in 11 and 12.

Ovaries: In 13.

Prostates: Large, racemose, muscular duct to male pores (no copulatory pouches).

Spermathecae: In 7-9, ampulla with half as long duct and tubular diverticulum.

Gut contents: ?

Remarks: *Amynthas asiaticus* appears similar to *A. hupeiensis* that is smaller and has genital markings in 17/18/19 and usually retains septa 8/9/10; and possibly to *A. alexandri* that has spermathecal pores in 5/6/7/8/9. Cf. *Metaphire virgo*, with copulatory pouches with prostate glands and spermathecae much reduced, and *M. tschiliensis*. Erstwhile reports as ‘dilong’, a part of traditional Chinese pharmacopeia (Ref., Ref.). *Amynthas asiaticus* occurs at 3,415 to 4,268m in Tibet (Michaelsen 1902); cf. *M. tibetana* (Michaelsen, 1931) that is poorly described and may be synonymous.

Amynthas aspergillum (Perrier, 1872)

Fig. 9a from Perrier's original figs. 71-72.

Fig. 9b by Chang *et al.*, 2009 (cf. Chen, 1959: fig. 13).

Fig. 9c sketch from RJB's Natural History Museum studies in 2013.

Perichaeta aspergillum Perrier, 1872: 118, Pl. IV, figs. 71-72. [Type localities Amoy and Kowloon, China. Type(s) in Paris MNHN 575].

Perichaeta aspergillum: Rosa, 1891. [Only noting material in Vienna Museum].

?*Perichaeta takatorii* Goto & Hatai, 1898: 76, fig. [From Taipei-fu, Taiwan; no types although some Taiwan specimens found in Todai (Blakemore & Ueshima, 2011].

Amyntas aspergillum : Michaelsen, 1899: 10; Beddard, 1900a: 631.

Pheretima aspergillum : Michaelsen, 1900a: 253 [non *P. aspergillum* : Beddard, 1888 (= *A. gracilis*)]; 1900b: 318 (?syn. *takatorii*); 1903: 94; 1929: 158; Chen, 1933? (syn. *paraglandularis*); Gates, 1935: 7,12 and Gates, 1939: 420 [syn. *lauta, paraglandularis, siemsseni* (part) – he inspected types of *lauta* and *siemsseni* but not of *aspergillum*, he also noted that *paraglandularis* was misidentified and that *paraglandularis omeimontis* Chen, 1931 is a separate species]; Gates, 1959b:1 (syn. *takatorii*; cf. *robusta*); Tsai, 1964: 29.

Pheretima takatorii : Kobayashi, 1939a: 659; 1939b: 778; 1940a: 120; 1940b: 274; 1940c: 391.

?[*Pheretima lauta* Ude, 1905: 405 (429?, 464?). [Locality Foochow. Types in Hamburg Museum: 10472].

Pheretima lauta : Chen, 1933: 282, fig. 26 (?syn. *siemsseni* Michaelsen, 1931: 17; *fokiensis* Michaelsen, 1931: 19 – note some authors mistakenly cite Michaelsen, 1930 or 1931: 574, but I have seen the original description and it is directly after that of his *siemsseni*, unless he published twice); Chen, 1933: 282, fig. 26 (??syn. *siemsseni* Michaelsen, 1931: 17; *fokiensis* Michaelsen, 1931: 19); Gates, 1939: 420 (inspected type 10472, as part of *aspergillum*); Ohfuchi, 1956: 155 (syn. *siemsseni*, *fokiensis*). Cf. *A. robustus* - Gates (1939: 482) seems to imply, while some later identified specimen may actually be *robustus*, the type of *lauta* = *aspergillum* and other authors put *lauta* = *aspergillum*].

Pheretima paraglandularis Fang, 1929: 15 (non *polyglandularis* Tsai, 1964). [From Kwangsi. Types in Nanking].

Amynthas aspergillus (?laps) et *aspergillum* : (*aeruginosus*-group) Sims & Easton (1972: 234; 240; 260) (syn. *paraglandularis*); Shih *et al.*, 1999 (syn. *takatorii*);

Blakemore *et al.* 2006: 227; Tsai *et al.*, 2009: 38.

Amynthas aspergillus: Tsai *et al.*, 2000: 286; Chang *et al.*, 2001: 76; 2003: 58; Tsai *et al.*, 2004: 5.

Diagnosis: *Amynthas* with two pairs of spermathecal pores ca. 0.3U apart in furrows 7/8/9 each pore surrounded on top and bottom by a total of about 7-9 fine glandular pores. Male pores paired superficial on 18 surrounded by ca. 8-11 GMs. Intestinal caeca simple **or deeply incised** from 27. Spermathecae with saccular ampulla and medium-sized diverticulum (glands from markings are nearby internally). Large size of 180-375 mm by 9-10 mm. Segments 118-150 and setae up to 100 per segment. 1st dorsal pore 11/12.

Distribution: China (Fuchow, Amoy and Kowloon), Hainan (Chen, 1938), Taiwan (Taipei and the islands of Lanyu and Kinmen) and Vietnam (as the BM specimen studied by RJB in 2013). Michaelsen said that Beddard's (1900) record of *A. aspergillum* from Japan was a mistake; however there is a recent report of "*Pheretima aspergillum*" from Iromoto-jima (Ref.). A Sao Paulo report by Righi (1967b) is more likely *A. robustus*, in fact this has recently been verified as *A. robustus* – (Ref.).

Remarks: *P. takatorii* Goto & Hatai, 1898 was shown with 8 markings paired around each male pore in chevron formation above and below male pore converging ventrally; other markings were around the spermathecal pores that had glands internally (mistaken by Goto & Hatai as extra spermathecae). *Amynthas aspergillum* (Perrier, 1872: 118) was confirmed by Chen to have two rows of markings ventral to spermatheca pores that correspond to those around the male pores.

The possibility that if markings vary, especially when reduced, then it mutually compares to *Amynthas robustus* (Perrier, 1872: 112) that is currently defined by its paired mid-ventral markings between male pores in a restricted definitions of this species. Beddard (1892) compared his *Pe. bermudensis* with *Pe. aspergillum*, but they clearly differ as the former has three pairs of spermathecae with no GMs nearby but Beddard (1900: 410) then again confused description of *bermudensis* by saying "*Spermathecae two pairs in VI, VII, VIII*"! But this is clearly a mistake of "two" for "three" spermathecal pairs.

Amynthas barbadensis (Beddard, 1892)

Perichaeta barbadensis Beddard, 1892: 167; Plate IX figs. 6-7.

Pheretima hawayana var. *barbadensis* : Michaelsen, 1910: 102 (Fuchow spex); Cernosvitov, 1934: 49, 1935:11 (Brazil spex).

Amynthas barbadensis : Sims & Easton, 1972: 236 (*morrisi* – group).

Remarks on possible synonyms of *Perichaeta barbadensis* Beddard, 1892: 167

Beddard (1892) confused his Plate IX fig. 6 compared to his descriptions on page 167 and a further mistake is that the marking he said was mid-ventral on 18 in the type is actually off-set to the right slightly (pers. obs.). He claimed specimen "a" was his fig. 6, but fig. 6 actually shows the specimen he describes as specimen "b" (that has spermathcae in 5/6/7/8 and which is almost certainly *A. gracilis*), while fig. 7 correctly shows the specimen he describes as "c" (with spermathecae in 5/6/7 and paired mid-ventral markings on 18 at least that is debatably *A. morrisi*). Beddard's (1895: 412) redescription of the three individuals gives little enlightenment and makes no comment on the figures being mixed (although he makes some acknowledgment that this was the case in a later Hawaii paper – Beddard, 1900).

More than thirty taxa correspond to Beddard's specimens "a" with spermathcal pores in 5/6/7 with simple caeca and superficial male pores. These are given below in order of priority, with those known to be especially similar, i.e., having mid-ventral markings (in specimen "a" as papilla presetally on 7 & 18), **shown bolded** – but full details not readily available for all taxa.

Because of this confusion, Blakemore (2014) has selected specimen "b" as lectotype making it a junior synonym of *A. gracilis* and thereby removing it from taxonomic consideration. Nevertheless, taxa complying with specimens "a" and/or "c" are:-

Amynthas	***morrisi***	(Beddard, 1892: 166)
Amynthas	***barbadensis***	(Beddard, 1892: 167)
Amynthas	*mauritianus*	(Beddard, 1892: 170)
Amynthas	*pallidus*	(Michaelsen, 1892)
Amynthas	*amazonicus*	(Rosa, 1894)
Amynthas	*sanctijacobi*	(Beddard, 1895)
Amynthas	*insulae*	(Beddard, 1896: 204)
Amynthas	*cupuliferus*	(Fedarb, 1898)
Amynthas	*lalangi*	(Michaelsen, 1923: 5)
Amynthas	*silvestris*	(Michaelsen, 1923: 16)
Amynthas	***hawayanus lineatus***	(Gates, 1926)
Amynthas	*choeinus*	(Michaelsen, 1927)

Amynthas	***incongruus***	(Chen, 1933)
Amynthas	*elutus*	(Gates, 1936)
Amynthas	*fibulus fibulus*	(Kobayashi, 1936)
Amynthas	*hainanicus*	(Chen, 1938: 396)
Amynthas	***monoserialis***	(Chen, 1938: 399)
Amynthas	*puerilis*	(Chen, 1938: 394)
Amynthas	*oculatus*	(Chen, 1938: 398)
Amynthas	*sinuosus*	(Chen, 1938) *in an *A. gracilis* gp?
Amynthas	***tripunctus***	(Chen, 1946: 85)
Amynthas	*gravis*	(Chen, 1946: 129)
Amynthas	*sapinianus*	(Chen, 1946: 130)
Amynthas	*loveridgei*	(Gates, 1968)
Amynthas	*geojeinsulae*	(Song & Paik, 1970: 103)
Amynthas	*nanulus*	(Chen & Yang, 1975: 89)
Amynthas	*plantopapillatus*	(Thai, 1982: 819)
Amynthas	*campanoporophoratus*	(Thai, 1982: 825)
Amynthas	*draconis*	Hong & James, 2001
Amynthas	*naejangensis*	Hong & James, 2001
Amynthas	*piagolensis*	Hong & James, 2001
Amynthas	*taebaekansis*	Hong & James, 2001

Interestingly, Sims & Gerard (1985, 1999: 132, fig. 47a) say "Amynthas morrisi *(Beddard, 1892a: 166) originally recorded as* Perichaeta barbadensis *Beddard, 1892a: 167 and* P. mauritiana *Beddard, 1892a: 170*". Thus the taxa above are progressive candidates for replacement by *A. morrisi* and/or the other two possible junior synonyms. Cf. *A. gracilis* and *A. loveridgei* (see below and Blakemore, 2014).

Amynthas carnosus (Goto & Hatai, 1899)

Fig. 2.3.4a *Amynthas carnosus* (Goto & Hatai, 1899) NSMT An435 Neotype showing prostomium, ventral view of body with spermathecae and prostates *in situ* (with GM glands nearby), septal glands on dorsal blood vessel, and intestinal caecum.

Fig. 2.3.4b *Amynthas carnosus*: top Goto & Hatai's original Fig. 4; bottom *Ph. kyamikia* Kobayashi, 1934; cf. syns. *youngtai* and *sangyeoli*.
Cf. Fig. 12 by Chang *et al.*, 2009.

Perichaeta carnosa Goto & Hatai, 1899: 15, figs. 4, 5. [From Tokyo - exact locality unknown; however, the authors worked at the First High School in Hongo near Ueno, Tokyo. Described on two specimens but these syntypes not located].

Amyntas hawayanus (part.): Beddard, 1900: 645; Gates, 1932: 433.

Amynthas gracilis (part.): Easton, 1981: 50.

Pheretima carnosa : Michaelsen, 1900: 260; Chen, 1936: 274 (when describing *P. pingi chungkingensis*, that now probably merits elevation to species level, remarked that *pingi* was probably a synonym of *carnosa*); Kobayashi, 1936b: 115, text figs. 1-3 (syn. *pingi*, *kyamikia*); Ohfuchi, 1937b: 56, fig. 9, Pl. I, 4; Kobayashi, 1938: 161; Chen, ?1959: 9, fig. 9 (syn. *pingi*); Gates, 1972: 149; Ishizuka, 2001: 75, fig. 32; Nakamura, 1994: 27 (name misspelt "canosa").

Pheretima pingi Stephenson, 1925: 891, text fig. 1 (of testis sac), plate II fig. 7 (of a probably parasitised spermatheca). [Lectotype in London, BMNH 1924:11:29:5 inspected by Blakemore, 2013 and found to be same as *A. carnosus*]. Michaelsen, 1931: 11; Stephenson, 1931b: 55; Chen, 1933: 228, fig. 15; Gates, 1939: 465 (inspection of British Museum types; ?non Gates, 1935: 14; nec Gates: 1943: 103?); Ishizuka, 2001: 82, fig. 46 (mislabeled "*Pheretima pingi* Chen, 1936") – looks exactly the same as *P. carnosa* in fig. 9 of Chen (?1959). [See separate descriptions below of "*A. pingi*" and cf. *A.corticis*].

Pheretima kyamikia Kobayashi, 1934: 1, figs. 1-3. [From Korea. Types lost]. [Kobayashi's fig. 1 is exactly the same as Chen's (?1959: fig. 9i variation). Named for Korean name "kyamiki" meaning "*dog bait*" or "*useless as fishbait*"].

Amynthas carnosus: Sims & Easton, 1972: 235 [in *A. hawayanus* (= *gracilis*) group]; Blakemore, 2003: 13 and 43 addenda (syns. *kyamikia,* ?*distichus*, ?*youngtai, sangyeoli*); 2005; 2007; 2008; Shen *et al.*, 2003: 484 (syn. *sangyeoli*); [?**non** Shen *et al*., 2005: 95, fig. 1 as their fig. 1 and description differs considerably from current concepts of *A. carnosus*]; Blakemore *et al.*, 2006: 228; Tsai *et al.*, 2009: 38; Chang *et al.*, 2009: 32, fig. 12; Blakemore, 2012: 35 (numerous synonyms and expanded distribution).

?*Amynthas youngtai* Hong & James, 2001b: 269, fig. 1A-C. [From Korea. Types in Korea?]. [Segments miscounted but, nevertheless, mostly agrees].

Amynthas sangyeoli Hong & James, 2001b: 271, fig. 3A-C with markings near male and spermathecal pores, and the spermatheca exactly the same as Goto & Hatai's figures from 102 years earlier, as well as those of Kobayashi, Ohfuchi, Chen, etc., etc.! [Rather than new, just another record from Korea; it is surprising how people who claim authority or expertise on Korean or Asian species can not have read ealier papers about, well, about Korean earthworms].

?*Amynthas nanshanensis* Shen *et al.*, 2003: 483.fig. 3, tab. 2 (the figure is similar to the range of variations of markings shown by Chen, ?1959: fig. 9 for *A.*

carnosus (but possibly the *A. pingi* synonym); Shen *et al.*'s table 2 is incomplete for genital marking variation of *carnosus*); Chang *et al.*, 2009: 64, fig. 28 shows markings (e.g. in 19) that differ from 'typical' *A. carnosus*. [From Taiwan].

?[*Amynthas monsoonus* James *et al.* 2005: 1012. From Taiwan. Cf. regarded as a junior synonym of *A. tungpuensis* Tsai *et al.*, 1999 by Tsai *et al.* (2009). Its similarity to *A. carnosus* was already suggested to the authors in manuscript review by Blakemore (2004) – referee's report sent to journal editor 8.i.2004 - here . See also the *M. huangi* débàcle].

Amynthas fuscus Qiu & Sun, 2012: 152, figs. 1C-D. [From Hainan]. **Syn. nov.**

Amynthas taiwumontis Shen *et al*., 2013. [From an island of Taiwan]. **Syn. nov.**

Amynthas carnosus carnosus : Blakemore & Lee, 2013: 132 (for Japanese neotype at least).

Notes: Prior taxon, *Amynthas divergens* (Michaelsen, 1892) (= *A. corticis*), has been mutually confused with *A. carnosus* during their long histories. Other subspecies are ***Amynthas carnosus roki*** Blakemore, 2013 from Incheon and Busan, Korea (and, Sept. 2017 from 99% compliance with Genbank KT252956, from South China); and ***Amynthas carnosus monstriferus*** (Kobayashi, 1936) in Blakemore & Lee (2013: 131) also from Korea. Regarding other putative sub-species of *A. carnosus*, it was already noted by Blakemore (2012a: 36) that *A. pingi chungkingensis* (Chen, 1936) probably merits elevation to separate species level as *A. chungkingensis*. This taxon was ascribed to "*Am. carnosus chungkingensis*" by Wang & Qiu (2005: 25, tab. 2) when comparing it to their *Amynthas carnosus lichuanensis* Wang and Qiu, 2005 from Mt. Xingdou, Hubei, China. This was also raised to separate species level as *A. lichuanensis* by Blakemore in Blakemore & Lee (2013) since it has no characters similar to revised concepts of *A. carnosus*.

Diagnosis: Size range 130-240 mm (or 110-340 Ref.). Four pairs of spermathecal pores in 5/6/7/8/9 (initially confused by Goto & Hatai as just in 5/6/7/8) or sometimes in just 6/7/8/9. Dorsal pores 12/13 or 13/14 (cf. *A. nanshanensis* in 5/6). GMs closely paired ventral and presetally in some of 7-8 or 8-9 and sometimes also in 18 and 19 with another pair posteriorly on 18 just posterio-median to the line of the male pores usually present. Intestinal caeca simple. **Note:** An apparently definitive characteristic, in the type and other confirmed specimens, is the post-setal pair of markings in 18 in

contact with, but median to, the male porophores.

Distribution: Japan (Goto & Hatai, 1899; Easton, 1981), Korea and Quelpart (= Jeju) Island (Kobayashi, 1936; 1938; Blakemore & Lee, 2013); in addition to these locations, from China - Jiangsu, Zhejiang, Anhui, Shandong, Hong Kong, Sichuan, Beijing (citation below) and Mt. Xingdou, Hubei, China, also Vietnam (as *P. pingi*). Recent doubtful claim from Taiwan by Shen *et al.* (2005), who ignore their earlier diagnosis and also overlook similarity with their Taiwanese taxa *A. tungpuensis* Tsai *et al*., 1999 and *A. nanshanensis* Shen *et al.*, 2003 that are also similar (the latter perhaps differing only in earlier dorsal pores commencement from 5/6 rather than 11/12 or 12/13) as is their *A. penpuensis* that, however, appears to lack genital markings entirely – as indeed in Shen *et al.*'s (2005) re-description of *A. carnosus* that appears to be an entirely different taxon [Cf. *A. corticis, A. fornicatus, A. sinsiensis* Hong & James, 2001: 272 (and its synonym *A. baemsagolensis* Hong & James, 2001: 274), etc.]. Recent claim from Kansas, USA (B. Snyder pers. comm., 2015) not confirmed as no DNA analyses attempted thus possibly some other taxon if not one of the known sub-species – despite my advice on these sub-species issues to the main author, this paper was nevertheless published in 2016 (Ref.).

In 2023-2024 Genbank records show that zzzz

Material inspected: NMST An 435, Neotype labeled "*Ph carnosa* (Goto and Hatai) Sendai-shi [Kanji for Sendai-city] 1923-1925" part of Saito Ho-on Kai Collection, possibly inspected by S. Hatai. The date indicates that it is not a syntype. One mature specimen with tip of tail amputated, previously undissected and here figured and dissected with small tissue sample taken for DNA analysis and (unsuccessful) barcoding. It should be appended to the redescription by Blakemore (2012) of *A. carnosa* (Goto & Hatai, 1899) that this same label location and date, possibly means simply that the specimens were in the collection in Sendai at that time and not necessarily from there; this means it could yet possibly be a missing syntype.

Description (compared to the original and some synonyms above)**:** Body length 180+ mm (cf. 130-240), segments 111+ (cf. 106-126). Dark brown dorsum with darker clitellum. First dorsal pore 12/13 (cf. 13/14). Spermathecal pores wide in 5/6/7/8/9 (initially confused by Goto & Hatai who described pores in 5/6/7/8 and then spermathecae in 7, 8 and 9). Genital markings closely paired presetally in 8 and 9 (in 7 and 8 according to Goto & Hatai, but probably this is a miscount, as with the spermathecae) and 18; other markings just anterioventral to superficial male pores in

18 postsetally plus a unilateral marking anteriorly and presetally in 19 (agree except those in 19 are paired as in 18, and in Goto & Hatai's second specimen the mid-ventral pair in 18 were missing); sessile glands correspond internally. Internally the pharyngeal mass extends back to 4. Septa 8/9/10 are aborted and 10/11/12 are strong. From 15/16 have distinct paired septal glands on dorsal blood vessel. Spermathecae in 6-9, the first pair often smaller and sometimes absent, with diverticula about half the length of the duct plus ampulla. Last hearts in 13. Seminal vesicles with dorsal appendages in 11 and 12. Ovaries in 13 with vestigial ovisacs in on posterior of 13/14. Intestine origin in 15 with simple caeca from 27. Gut contains yellow soil only, i.e., low organic content.

Note: The exact Tokyo type locality is not known; however, the authors worked at the First-High-School, Tokyo which is in Ueno (if they collected there). Possibly endemic to Japan/Korea and China and introduced to Taiwan, unless, as Chen (1936: 275) first suggested when describing *A. pingi chungkingensis*, that *A. pingi* is a synonym of *A. carnosus*, in which case this taxon may be more prevalent in China and its centre of origin more obscure. Gates (1943) describes a single specimen of *Pheretima pingi* from 3,000-5,000 ft at Kuatun, Fukien China and makes no mention of the supposedly distinctive tubercules (parasites) on the spermathecae. The genital markings of this specimen were nearly coincident with the spermathecal and male pores plus another two pairs just median to the male pores, one presetal and one postsetal, the latter in contact with, but distinct from, the male porophore; thus it is doubtfully synonymous.

Remarks: A problem with the original description was that the spermathecal pores were described in 5/6/7/8 but spermathecae were stated to be in 7, 8 and 9, suggesting they exited in 6/7/8/9 but it seems one set was missed and they were actually in 5/6/7/8/9. While Gates (1972: 149) implied this taxon, plus *P. pingi* and *P. kyamikia* etc., might be the same as *Megascolex diffringens* Baird, 1869 [= *Amynthas corticis* (Kinberg)] that has four pairs of spermathecal pores, Easton (1981: 50) tentatively included *P. carnosa* in synonymy of *Amynthas gracilis* apparently accepting three pairs of spermathecae in 5/6/7/8 as per the original description and as innocently restated by Michaelsen (1900: 260). Nevertheless, Kobayashi (1936) and Ohfuchi (1937b: 56) in more detailed descriptions, found it with four pairs of spermathecae in 5/6/7/8/9 and with variations in markings that encompass Kobayashi's *P. kyamikia*, thus it appears different from both *A. gracilis* and *A. corticis* by its markings described as more closely paired,

almost mid-ventral, in some of 7,8-9 and 18, 19. Ishizuka (2001: 75) also figures *carnosa* with four pairs of spermathecae in 5/6/7/8/9 and with markings paired in 8 (two sets), 9, and 18 (two sets). *A. carnosus* is restored from Easton's synonymy in *A. gracilis* in the present account. [The Chinese distributions above are from Chinese Agricultural Academy of Science website www.agrionline.net.cn/zhuanti/index.htm (2005) whence *Pheretima carnosa* is described with either three or four pairs of spermathecae in 5/6/7/8,8/9].

Kobayashi (1936: figs. 1-2) studied 204 Korean specimens with variations of up to eight markings in some of 7-9 and six or fewer in 18-19 that encompassed genital marking variations found in *A. pingi*, and several specimens lacked markings. Kobayashi also found two specimens with spermathcal pores in 6/7/8/9 only.

Hong & James (2001b: 271, fig. 3) start to describe *A. sangyeoli* directly above their fig. 2 of an allegedly different other species (as if to cause as much confusion as possible!) but they do manage to count the segments correctly in their fig. 3 (cf. their fig. 1) as they describe a "*sp. nov.*" in exact agreement with both *A. carnosus* (Goto & Hatai, 1899) and Kobayashi's, 1934 *P. kyamikia* from Korea that also does not differ from Kobayashi's and Ohfuchi's redecriptions of *A. carnosus* where the spermathecae are located in 5/6/7/8/9, as in their own *Amynthas youngtai* (that has its figured segments miscounted). This proves that Hong & James have not read and/or not understood any previous Japanese nor Korean papers (!) and that their taxonomic competency must be questioned. Rather than being a "*sp. nov.*" their *A. youngtai* is exactly the same as *A. carnosus*. The *A. sangyeoli* synonym was also independently determined by Shen *et al.* (2003b: 484, Tab. 2) before her co-authored and confused redescription of *A. carnosa* from Taiwan. Moreover, *Amynthas monsoonus* James *et al.* 2005: 1012 from Taiwan is similar to *A. carnosus* as it has the same classical markings in 7-9, but its spermathecae are in 6/7/8/9 and, as originally described (mistakenly?) by Goto & Hatai (1899) and as found in 2 of 204 of Kobayashi's (1936) specimens, thus in the current revision it is permitted as a rare interspecific variation.

With considerable oversight verging on arrogance, most of Hong & James species are only compared to Hong & James' species and, as a shameful cynical disservice to all current and future workers, they allow their clearly synonymous names to remain on GBIF and Korean Earthworm websites [e.g. - http://data.gbif.org/species/search.htm?c[0].s=1&pageno=2&c[0].o=465&c[0].p=0 and http://geoworm.ccbb.re.kr/renew/index.php (accessed May, 2010)] and to be quoted in

Agricultural research papers [e.g Na *et al.* (2010 DOI: 10.1007/s00244-010-9527-0)].

Shen *et al*.'s (2005: 95, fig. 1) later redescription of *A. carnosus* seems to be based on some other taxon as the genital makings and spermathecae (their fig. 1) differ considerably from those in current concepts of *A. carnosus*. For instance, the markings are small and numerous around the spermathecal pores and the spermathecal diverticular are long and more dilated, looking paprika-like. Thus their identification is suspect. Similarly, Gates' (1935; 1943) concept of *A. pingi* seems somewhat removed from the present idea of *A. carnosus* and its identity, not to mention its combination in *A. carnosus*, may be questioned. Both listings are now excluded from synonymy and the "*A. pingi*" synonym is briefly described separately below to show how it now integrates with *A. carnosus* proper.

The *A. carnosus* species complex is also comparable with parts of the *A. corticis* and *A. exiguus* spp-complexes as described by Blakemore (2002, 2006, 2008) and as noted below.

The sub-species ***A. carnosus narabunji*** Blakemore, 2013 with Holotype from Incheon Great Park, Korea has the following type DNA:

The sub-species ***A. carnosus roki*** Blakemore, 2013 was described with caution as "*This taxon is particularly similar to* A. monstriferus *(Kobayashi, 1936), differing not least on the lack of markings on segment 8, and possibly they should be merged*." Its Holotype (H) from Incheon Great Park, Korea has the following type DNA:

>w56 Large ***A. carnosus*** from Incheon (300 mm) later identified as **A. c. roki** Blakemore, 2013 H.
CTATACTTTATCTTGGGAATCTGAGCCGGAATAATTGGTGCGGGTATAAGACTCCTTATT
CGAATCGAGCTCAGACAGCCGGGATCCTTTCTAGGAAGAGATCAGCTATACAATACAAT
TGTGACAGCCCACGCATTCCTCATAATCTTCTTTCTAGTTATACCCGTATTCATCGGGGG
GTTTGGAAATTGACTACTACCACTCATACTAGGAACACCGGATATAGCATTTCCACGCCT
AAACAACATGAGATTTTGACTATTACCACCATCACTAATCTTACTGGTCTCTTCTGCCGC
AGTAGAGAAGGGGGCGGGAACAGGGTGGACAGTATATCCTCCCCTAGCAAGAAATATC
GCTCATGCGGGGCCATCAGTAGACCTAGCAATTTTCTCACTCCACTTAGCTGGGGCGTC
CTCAATTTTGGGGGCCATTAACTTTATTACTACAGTAATTAATATGCGCTGATCTGGACTA
CGTCTAGAACGGATTCCACTATTTGTGTGAGCAGTAGTAATCACTGTGGTACTACTATTA
CTATCATTACCAGTTCTTGCCGGAGCTATTACAATACTACTAACAGACCGAAACCTAAAT
ACATCATTCTTTGACCCAGCGGGAGGAGGGGACCCAATTTTATACCAACACCTATT
Blastn showed that this taxon also occurs at Busan (from my studies), also 99.85% as JT252956 from "South China" in 2015. Thus it is here considered a Cosmopolitan.

***Amynthas corticis* species-complex** *sensu* Blakemore, 2003: 14

[Consisting of *A. corticis*, the representative taxon, with progressive priority synonyms].

Amynthas corticis (Kinberg, 1867)

Fig. 2.4 *Amynthas corticis*, Mt. Cotton specimen (a) ventral view, (b) duct of aborted prostate, (c) spermathecae; (d) prostomium; (e) intestinal caeca and dorsal blood vessel with 'lymph' glands; (f) posterior.

Fig. 2.5 *Amynthas corticis*, Samford specimen (a) ventral view, (b) *Monocystis* at site of aborted prostate, (c) spermathecae infected with *Monocystis*; (d) prostomium; (e) intestinal caeca and dorsal blood vessel and 'lymph' glands; (f) posterior.

Perichaeta corticis Kinberg, 1867: 102. [Type locality Oahu, the main Hawaii Island. Types in the Stockholm Museum: 1947, possibly immature].

Megascolex (*Perichaeta*) *diffringens* Baird, 1869a: 40 & 1869b: 387. [Original account of this species is presented below in full under *A. diffringens*]. [Type locality Plas Machynlleth, North Wales. Type in British Museum: BMNH 1869:1:2:1, inspected by author in 2012 and 2013 but not presently recovered at type-locality (pers. obs. 22nd VI 2013 as published by Blakemore, 2013)].

?[*Megascolex* (*Perichaeta*) *sanctaehelenae* Baird, 1873: 96. Collection details: High ground at St Helena, collected by I. or J.C. Melliss, Esq. Type BMNH 1869:6:16:5 – found on inspection by RJB on 24.IV.2012 and VI.2013 to be a juvenile damaged by dissection with spermathecae and prostates absent/removed; status: *incertae sedis*].

Perichaeta subquadrangula Grube, 1877: 553. [Type locality Fiji. Types in Berlin, 705]. [Note: Due to its poor description, Sims & Easton (1972: 224) had this species name (with incorrect date as "1868: 36") as *incertae sedis*, but Easton (1979: 119; 1984: 118) placed it in synonymy of *corticis*].

[*Perichaeta sp.* Horst, 1878: 103 (= *Megascolex indicus* Horst, 1883: 186 part.?)].

Megascolex indicus Horst, 1883: 186 (part?). [Type-locality: Sumatra and Java. Types reportedly in Leiden Museum 1917-8 (cf. Gates, 1949: 526 where he says locality "*unknown*" and also questions the existance of Leiden types)]. [Non *Perichaeta indica*: Horst, 1885: 4, i.e., *Megascolex indicus* as redescribed by Horst, 1885 (= *Pheretima darnleiensis*); cf. Gates (1935b) where he misdescribes *indica* (Horst, 1883) as *P. darnleiensis* – see Sims & Easton (1972: 260) and cf. *P.*

darnleiensis description herein].

Perichaeta ungulata (laps. pro. *cingulata*) Bell, 1886: 21.

Perichaeta indica: Beddard, 1890: 52,57, Pl IV figs. 1-3, Pl V, figs. 4-6,8,9.

Pheretima indica (part): Michaelsen, 1894; 1900: 275 [syn. ?*corticis* (priority?), *heterochaeta*, *nipponica*].

Perichaeta peregrina Fletcher, 1886/7b: 969. [Type locality plant pots from a nursery in Sydney, believed introduced from Mauritius. Types in Sydney? Untraceable at Macleay Museum, at the University of Sydney - Dr Margaret Humphrey, Curator, Entomology pers. comm. to RJB, April, 2005]. [Authorship dated "1886" e.g. by Michaelsen (1900); dated "1887" by Sims & Easton (1972: 239, 260); Easton (1983: 732; 1984: 119). "*The part containing Fletcher's paper was actually published on 17 November 1886*" (M.L. Augee, Editor, *Proc. Linn. Soc. NSW* pers. comm. to RJB, Oct. 2004) although the journal, now pubished online, is clearly dated "1887"]; Michaelsen, 1900: 293 (syn. ?*molokaiensis*).

Amyntas peregrinus : Beddard, 1900a: 644 (part. ?syns. *molokaiensis, floweri* – not all subsequently agree cf. *P. darnleiensis*); 1900b: 414 (Hawaiian earthworms, syns. *molokaiensis, floweri*).

?Perichaeta mirabilis Bourne, 1887: 668. [Naduvatam, Nilgiris, India. Types?].

?Perichaeta sp. Garman, 1888: 74. [From Illinois (the first continental USA record?)].

Perichaeta heterochaeta Michaelsen, 1891: 6. [Azores. Types lost]; Michaelsen, 1900: 275 (under *indica* with other synonyms *?corticis, diffringens, ungulata* (laps. pro *cingulata*), *heteropoda* and *nipponica*).

Amyntas heterochaeta ; Beddard, 1900a: 622 (syn. *indica* auctorum non Horst, *perkinsi, modigliani, nipponica, mirabilis*); 1900b : 416 (Hawaiian earthworms, syn. *nipponica*? – described with no GMs or paired or unilateral in some of 6-9).

Pheretima heterochaeta : Michaelsen, 1900; 1907: 226; 1911: 142, etc.

?*Perichaeta ijimae* Rosa, 1891: 402. [Type locality Japan. Types Vienna?]. [Spermathecae adiverticulate in 5/6/7/8, cf. *A. gracilis*, *A. micronarius* and the recent Taiwanese *A. quadriorbis* Shen et al. 2016 in a publication that, tellingly, omits any citations of Blakemore's many revisions of these taxa and cannot be compared to my DNA data for *A. micronarius* from Nogeyama or Korea because their promised GenBank KU 232820 has yet (August, 2017) to be uploaded].

Perichaeta divergens Michaelsen, 1892: 243, tab. 13, fig. 21. [Type locality Japan. Types Berlin, 2116 "*Hilgendorf rp.*", now lost according to Hartwich & Kilias (1989:

260) and not located in BMNH either – RJB pers. obs.]. [Prostates aborted].

Amynthas divergens; Michaelsen, 1899: 8 (?syns. Goto & Hatai's *fuscata, campestris, kamakurensis, parvula, heteropoda, obscura, scolastica, decimpapillata, flavescens, producta, micronaria*).

Pheretima divergens: Michaelsen, 1900: 264, 314-317 (?syn. *fuscata*, *campestris*, *kamakurensis*, *parvula*, *heteropoda*, *obscura*, *scholastica*, *decimpapillata*, *flavescens*, *producta*, *micronaria* – all Goto & Hatai, 1898; all from Japan; but the latter one, at least, is doubtful); Ohfuchi, 1937: 67-108, tabs. 1-25, figs. 11-28 (without including any synonyms of Michaelsen!).

Amyntas divergens : Beddard, 1900a: 625 (syns. *fuscata, heteropoda, obscura, scholastica, micronaria, grossa* – several after Michaelsen, 1892, 1899).

Perichaeta nipponica Beddard, 1892: 760. [Japan. Type BMNH 1904:10:5:993 – no longer traceable in the collection there, E. Sherlock per. comm, IV.2012 and RJB pers. obs. VI.2013]. [Beddard (1895: 413) said that the main peculiarity of the single specimen of this species was the spermathecae: "*each has a diverticulum longer than pouch; to these are appended a variable number of small globular sacs;*" – possibly parasites as reported here; he also noted papillae anteriorly in 7-9 with glands internally and the lack of prostates].

Pheretima nipponica: Michaelsen, 1900; Ohfuchi, 1937: 108-133, fig. 29-36; Kobayashi, 1941b: 258 (an unlikely junior syn. of *californica*).

?Perichaeta perkinsi Beddard, 1896: 198. [From Hawaii. Types missing? Not found in BMNH pers. obs. RJB VI.2013]. [Spermathecae 5/6/7/8/9; possibly a separate, although exotic, species/variety].

?Perichaeta molokaiensis Beddard, 1896: 201. [From Hawaii. Types missing? Not found in BMNH pers. obs. RJB VI.2013]. [Spermathecae 5/6/7/8/9].

Perichaeta heteropoda Goto & Hatai, 1898: 69. [Japan. Types none – confirmed RJB (Blakemore & Ueshima (2011)]. [Spermathecae 5/6/7/8/9. GM in 6-9 paired and pre-setal – it is only the markings in 6 that separate it from *A. diffringens* types, pers. obs. Name yet retained by some contemporary Japanese and/or Koreans sometimes as "*Amynthas heteropodus*" or "A. *heteropoda*", or misspelt as "*heteropadus*"; for example Hong & Kim (2009) and Dr Young Hong again presented this as a contemporary Korean species at a seminar in Incheon in September, 2012 (my email notification to him accepted on 25th Sept, 2012)].

Pheretima heteropoda : Ohfuchi, 1937: 42-50, figs. 4-7 (part?).

Amyntas peregrinus : Beddard, 1900b: 414 (syn. *floweri* [cf. *darnleiensis*], *molokaiensis*).

Amyntas heterochaeta : Beddard, 1900b: 416 (syn. *indica* Michaelsen, 1892: 33; non Horst; ?*nipponica*, ?*perkinsi*).

?Pheretima marenzelleri Cognetti, 1906: 780, figs. 5-6. [From Yokohama. Type Vienna?; Kobayashi, 1938: 407, figs. 1a-b (recorded from Hokkaido and, p. 408 footnote: non Ohfuchi (1936); redescribed by Blakemore (2012); still quoted as valid by Shen et al. (2013) for some reason].

?Pheretima silvestrii Cognetti, 1909: 266. [From Hawaii. Types Turin 194].

Pheretima divergens yunnanensis Stephenson, 1912: 274. [From Yunnan. Type Calcutta (5062)]. [Mistaken by some subsequent workers as "*P. browni yunnanensis*". Gates (1939: 430) inspected the fragmented type(s)].

[*?Pheretima pingi* Stephenson, 1925b: 891 (cf. *A. carnosus*)].

?*Pheretima indica* var. *cameroni* Stephenson, 1932: 47, fig. 4. [From Cameron Highlands, Malaya. Type in London, possibly missing? Not found in BMNH pers. obs. RJB VI.2013]. [A single poorly preserved specimen with spermathecae in 5/6-8/9 no nephridia on ducts; no markings - probable **syn. nov.** of *corticis* that was added by Blakemore (2013)].

Perichaeta mirabilis: Gates, 1934: 50 [?non Bourne, 1887: 669].

?Pheretima sheni Chen, 1935: 38. [From Hong Kong, eight specimens three of them aclitellate and all lacking spermathecae. Type described in the Museum of Fan Institute of Biology, Peiping (Beijing) but also claimed in US National Museum]. [Cf. *Amynthas robustus*, *A. illotus*].

?Pheretima directa Chen, 1935: 47. [From Hong Kong; three specimens, the type described in the Museum of Fan Institute of Biology, Peiping but also claimed in US National Museum: 20183]. [Because some genital markings are lateral to the male pores it is possible that this is a valid species].

?*Pheretima oyamai* Ohfuchi, 1937: fig. 10, Pl. I, 3. [From Morioka, Iwate-ken and Odate, Akita-ken. Types? The spermathecae are adiverticulate and GMs only on 18; exactly as he shows for his subsequent redescription of *Ph. divergens*! But caeca are simple and smooth. Cf. *A. carnosus* as an adiverticulate morph?].

Pheretima tajiroensis Ohfuchi, 1938: 46, figs. 12-14. [From Tajiro Island, Miyagi-ken. Types? Parasitized spermathecae & prostates mistaken as characteristics].

?*Pheretima homoseta* Chen, 1938: 414. [From Hainan. Types? Restored in some latest accounts as *Amynthas homosetus* but without good reason. Originally as

Pheretima homochaeta, an 'incorrect original spelling' (ICZN, 1999: Art. 32.5.1.1) subsequently corrected to *Pheretima homoseta* by Chen (1938) in an ERRATA sheet to his *homochaeta*].

?Pheretima morii Kobayashi, 1938: 161, fig. 15. [From Korea. Types not known. SP in 5/6/7/8/9, GMs in 7-9, and just before male pores; prostates aborted].

?*Pheretima toriii* Ohfuchi, 1941: 244, fig. 2. [From cave, Oita-ken. Types? Small ~40 mm and lacking GMs, possibly a distinct species].

?*Pheretima clerica* Benham 1947: 423, Pl. 1, figs. 1-5. [From Gisborne district in NZ. Types? There appears some slight difference in that male pores are in small slits and there is a genital papilla on the inside of each; prostates are present].

Pheretima campestris Lee, 1952: 39. [From New Zealand (and Kermadec). Types Te Papa, W.000494 Ref.]. [Placed in synonymy of *P. peregrina* (Fletcher, 1887) (= *Amynthas corticis*) by Lee (1959: 327); non *P. campestris* Goto & Hatai, 1898 (?= *Amynthas robustus*)]. [Non senior secondary synonym *P. campestris* Goto & Hatai, 1898: 67].

?*Pheretima hatomajimensis* Ohfuchi, 1957: 245 [Japan. Types? Separated by Blakemore, 2013].

Pheretima diffringens: Gates, 1934; 1935; 1937: 412, 450; 1939: 430 (syns. *divergens* var. *yunnanensis, divergens, heterochaeta, mirabilis*, *corrugata* – a very confused mish-mash of names and partial description by successive authors suggesting that Gates was either terribly unreliable with all his work needing to be re-checked, or actually quite unorthodox); 1943: 102 (genital markings on 7-9 midway between furrows and setal arcs, heats of 10 lacking, prostate glands absent but gential marking glands in 18 are just median to prostatic ducts); 1959b; 1972: 149, footnote 2: [?syns. (some in part) *californica, campestris, cingulata, clerica, corticis, divergens, heterochaeta, heteropoda, indica, mirabilis, molokaiensis, nipponica, peregrina, perkinsi, sanctae-helenae, silvestrii, tajiroensis, torii, ?carnosa, ?directa, ?homoseta, ?kyamikia, ?morii, ?oyamai, ?pingi*]; Gates, 1972: 177 (syn. *heterochaeta, divergens yunnanensis, mirabilis*); Gates, 1972: 217 (?syn *sheni*); Gates, 1972c: 18,27 (syn. *divergens, heterochaeta, heteropoda, indica, nipponica, oyamai, tajiroensis, ?toriii*); 1982: 44 (yet more confusion and defiantly retained in wrong genus despite his knowledge of Sims & Easton, 1972).

Amynthas diffringens: Easton, 1979: 119 (syn. ?*subquadrangula*); Hong & James, 2001: 92 (i.e., more than 20 years after it was shown by Easton, 1981 to be *A. corticis* synonym and 12 years before it was restored by Blakemore, 2012!).

Amynthas corticus (sic lapsus pro *corticis*): Sims & Easton, 1972: 235, 241; Easton, 1981: 49-50 (syn. *diffringens, divergens, ?hatomajimensis, heterochaeta, heteropoda, ?ijimae, indica* Horst, 1883: 186 (sic lapsus Easton, 1981 pro *indicus*), *?marenzelleri, nipponica, oyamai, tajiroensis, toriii*).

Amynthas corticis: Easton 1982: 726-728 (syn. *diffringens*, *peregrina*, *heterochaeta*); Easton, 1984: 118 (syn. *subquadrangula*); Sims & Gerard, 1985, 1999: 128 (syn. *diffringens*, *indicus*, *nipponica*); Blakemore, 2002, 2003: 14 (listing above syns. plus about a dozen extra synonyms from Japan – note that those names from a Mr Kotaro Ishizuka are now deemed invalid due to failure to meet ICZN 1999: Art. 11.4), 2005, 2007, 2008, 2010.

[*Amynthas gajulanus* James *et al.*, 2004 MS syn. prevented by Blakemore, 2004].

Amynthas nanrenensis James *et al.* 2005: 1008, fig. 2A,B (on p. 1010). [From Taiwan, types NMNS 4054-001,2. Erection of this MS name was questioned by Blakemore, 2004 and its partial justification on its "*arrangement of genital markings in the male field*" shows little distinction from Gates' (1972: 178) "*one or more near each male porophore*". Neither was it compared to any of the 40 or so synonyms above – a task presumably left to subsequent workers]. **Syn. nov.** added by Blakemore (2013).

?*Amynthas chilanensis* Tsai & Tsai, 2007 in Tsai, Shen *et al.* **Syn. nov.** [Yet another speculative Taiwan parthenogen, claimed to be similar to *A. sheni* (= *A. corticis*)].

Taxonomic Notes: The name *corticis* is sometimes misspelt "*corticus*" or "*coritcis*". It is not certain that all subspecies of *Megascolex indicus* Horst, 1883 s. strict. (cf. *Pheretima darnleiensis*) follow it into synonymy of *corticis*; these subspecies are listed by Sims & Easton (1972: 235) as: ***Amynthas indicus cameroni*** (Stephenson, 1932) from the Malay Peninsula; ***Amynthas indicus ceylonicus*** (Michaelsen, 1897: 246) from Sri Lanka; and ***Amynthas perkinsi*** (Beddard, 1896) from Halemanua and Kauai, Hawaii which was included by Michaelsen (1900: 276) as a 'variety' of *indica*. It appears to me that there is nothing substantial in the description of *A. cameroni* to differentiate it from *A. corticis*; and certainly the latter two taxa are not endemic to their localities. Stephenson (1923: 302) includes *ceylonica* (and its variant mispelling "ceylanensis" in *P. heterochata* (= *A. corticis*); and Gates (1972:149) includes *A. perkinsi* as a possible

synonym of *corticis* in a footnote where he lists the names under which specimens of *P. diffringens* have been referred to as, or have been types of. *A. perkinsi* was based on two specimens, neither with genital markings, that, however, had complete spermathecae and prosates; probably the same as *A. corticis* as is the almost identical *A. molokaiensis* (Beddard, 1986).

Note on Tsai, Huei-Ping Shen *et al.* (2007: 376) critisism of Easton (1981) & Blakemore (2003), etc.: These authors question the rationale and validity of listing possible synonyms with a "?" for the obvious reason to raise some degree of uncertainty. They use ICZN to support their claim but seem unaware of ICZN (1999: Art. 5.3: "*A typographical sign such as ?, and an abbreviation such as aff., prox. or cf., when used to qualify the application of a scientific name, does not form part of the name of a taxon...*" These authors stated: "***It should be clearly proven that the synonym is within the boundaries of species delimitation of the other species. Using speculative synonyms with question marks (without reasoning) to deny the specific status of nominal species (Easton 1981; Blakemore 2003; Blakemore et al. 2006), and arbitrarily consider parthenogenetic nominal species as reproductively degenerated morphs (Blakemore 2003) to reject their specific status undoubtedly underestimates the biodiversity of the earthworm fauna of Japan, and creates confusion in oligochaete taxonomy***."

They then have a pointless diversion about the ecology of parthenogentic morphs being valid. Rather obviously, that is probably so at certain levels of observation, but this is a distraction from the key issue of ICZN NOMENCLATURE NOT ECOLOGY. Since these four Tawian authors claim some authority so must they accept responsibility to support their flippant statements and are thus invited to "**clearly prove**" the 150 year quandry of *A. corticis* synonymy, now with about 50-60 possible or probable names, including their own *Amynthas chilanensis*! They must also separate their *A. shinanmontis* from *A. gracilis* and their *A. cruxus* from *A. hotomajimensis*! Tellingly, in the intervening decade they seem to have made little or no contribution to such resolution. Perhaps this is because they realize, as had Easton & Blakemore before them, that such a task may well take more than a decade of full-time research at a high cost in personal time, efforts, finances and flak. Tsai, Shen *et al*. (2007: fig. 5, tab. III) compared "*A. corticis (= P. diffringens, Taiwan)*"; "*P. heterochaeta (= A. corticis)*" and cite *A. pingi* (Chen, 1933), yet it was left to Blakemore (2012, 2013, 2016) to resolve the status of *A. diffringens* (an apparently seperate taxon to *A. corticis*) and *A.*

pingi (a junior synonym of *A. carnosus*) based on huge personal effort & expense to inspect & determine types. Further onus is thus on the shoulders of these authors to obstensibly resolve all other similar problems themselves, under the IZCN Principle of Priority, or to withdraw their trite gripe (contact is shenhp@tesri.gov.tw if you want to get a copy of her paper unless you want to pay many $$s, and for clarifications). For example, they need to identify all the prior synonyms of *A. corticis* , let's just say *A. ijimae* (Cognetti, 1891) – the Vienna type needs to be inspected and a topotype rediscovered from "Japan" to provide DNA to compare with all prior synonym types/neotypes/topotypes, this taxon then needs to be compared to the half-a-dozen or so prior syonyms (with misidentifications) of *A. corticis/diffringens/indicus.* These four Taiwan authors can do this themselves, or they can pay me to do it competently. But probably it would take five to ten years of full-time research with an expense and travel budget appropriate to such a task. Unless they can offer a similar solution then their rhetoric is purely a smoke-screen for incompetence. Ten years on I am still eagerly awaiting their reasonable explanation... and perhaps an apology or retraction?

Diagnosis of *A. corticis*: *Amynthas* with four (or fewer!) pairs of spermathecal pores ca. 0.3 body circumference apart in furrows 5/6/7/8/9 [all, or just posterior pair (?or anterior pair) rarely lacking]; genital markings small paired and variable near spermathecal and male pores, often widely paired. Intestinal caeca simple with smooth margins (or incised with age in older specimens cf. *A. divergens*?), originating near segment 27. Prostates often aborted, sometimes present. Parthenogenetic and parasitized morphs common (e.g. lacking prostate glands and/or with partially or wholly aborted or adiverticulate spermathecae). [*A. diffringens* with pre-spermathecal marks and *A. divergens* with its serrate caeca are provisionally removed (Blakemore, 2013) and at least two different lineages of *A. corticis* were detected, but it remains uncertain which prior taxa are involved].

Distribution: According to Beddard, 1893, its occurrence is "*everywhere, including Europe*". This species is the most widely distributed of the allochthonous species of the pheretimoid group, having been recorded from temperate and tropical regions throughout the world, although it seem to have failed to establish in certain European countries and tropical lowlands of India (Gates, 1972: 179). Sims & Easton (1972: 257) report it from Papua New Guinea, perhaps for the first time. Righi (1965) reports it from Brazil (as *Pheretima indica*) and Brown & Fragoso (2007) list it from Ecquador, Bolivia,

Argentina, Colombia, Guatamala, El Salvador, Panama, Mexico, Jamaica, Cuba, Venezuela, Domincan Republic and Peru. Tropical records are rarer, and usually from higher altitudes e.g. 1,100-3,600m in Colombian Andes (Feijoo *et al.* , 2004). The indigenous and self-acquired range of the species is perhaps in northern China, Taiwan, Korea, Japan (Gates, 1972: 178, 180); or in high altitudes in east and south-east Asia e.g. in Nepal, northern Pakistan, northern India, Myanmar and southern China (Sims & Gerard, 1985: 128) (cf. *Amynthas pingi* as described herein). Bali is possibly a **new record** for Indonesia (collected by RJB 28th Sept, 2010 under coconut husks near Ubud). Japanese/Korean populations of this species have been frequently and repeatedly described, which may be due partly to the variability of the degraded morphs, but also relates to the inexperience of the workers in those countries who unnecessarily erected new names. In the past, *A. corticis* was reported under names of its junior synonyms such as *Pheretima diffringens* or *P. peregrina* (e.g. from NSW and New Zealand - see Lee, 1959) or in earlier papers as *P. heterochaeta* (from Nowra, NSW by Stephenson, 1931; and WA by Jackson, 1931). In Australia it was first reported by Fletcher (1886) in plant pots from a Sydney nursery and it was also recorded from Qld., NSW, WA, Lord Howe Island (see Easton, 1982). In UK, recorded from greenhouses an conservatories in Dumfries and Galloway (Maxwelltown); Cumbria (Kendal); Cheshire (Holmes Chapel); Powys (Machynlleth); Suffolk (Bury St. Edmonds and Woodbridge); Hertfordshire (St. Albans); and Surrey (Kew) – (Sims & Gerard, 1985: 128); and Gates (1982) records it from Scotland. Dublin Botanic Gardens is **new record** for Ireland (RJB, 2010 from material sent by Dr Olaf Schmidt). Recently found in New Zealand (also present were lumbricids *E. japonica* and *L. rubellus*) in swampy paddock beside steaming pool at Arataki Honey facility, Waiotapu in Taupo district of Waikato region by RJB 28th Nov., 2011. **New record:** "*Isfiya, Mount Carmel, Israel, Gardencenter Aug. 4. 2005 leg. Tomas Pavlicek*"; six spex, ID RJB. (one spec dissected), 4th April, 2022.

Locality: Brookfield, Samford, Mt Cotton, Mackay, Qld; Budderoo Plateau, NSW; Adelaide, SA; Tasmania, in garden soils and wormfarms - new records. Numerous other specimens inspected were from Tokyo/Yokohama/Mishima, Korea and Santa Rosa, San Cruz, Galapagos Islands (collected M. Mantilla/M. Nakamura, 1994-VII-4) - new records. Other specimens were from Taupo NZ and Israel (new record), as noted above.

Habitats: Various habitats are listed by Gates (1972). In present studies, found in farm and garden soils and wormfarms; on soil and road surfaces in early mornings, under pasture and *Leucaena*, riverbanks under litter and logs/stones. Reported by Stephenson

(1925) as one of the commonest worms of the Himalayas, e.g. from bed of hill stream in Darjeeling at 7,000 ft (2,000 m) from Mt Everest Expedition [with *Amynthas himalayanus* (Stephenson, 1925) and *Eisenia fetida*].

Behaviour: Often a vigorous lashing when exposed and rapid snaking escape; yellow coelomic fluid ejected and possible autotomy of caudal segments.

Length: Often in range 120-160 mm (pers. obs. cf. 45-270 mm, Sims & Gerard); body circular in section. Benham (1946) draws attention to the different widths of segments, which he measures and figures in detail; those in 10 being widest longitudinally.

Width: 3-5 mm, (*P. marenzelleri* is 6-7mm).

Segments: (78)105-110 (121), (*P. marenzelleri* has 138).

Colour: Dark chocolate brown or greenish-brown, green-iridescent dorsum; ventrum paler; clitellum yellowy buff.

Prostomium: Wide open (almost parallel) epilobous; ventrally cleft.

First dorsal pore: (10/11), 11/12 or 12/13, not always obvious on clitellum, but seen in dark dorsal line thereafter.

Setae: Numerous, ca. 28-55 per segment; sometimes slightly larger ventral setae in anterior segments; ventral series often partly visible on clitellum.

Nephropores: None found.

Clitellum: Annular in 14-16, furrows and setae faintly retained or obscured.

Male pores: Superficial 0.3 circumference apart on depressed corny pads, equatorial and insunk in 18, ventral furrows 17/18 and or 18/19 may be obscured by tumescence. Ten or more setae between the male pores. [Note: retraction of male porophores on preservation may cause hollows, not to be confused with the slit-like apertures of related genera *Metaphire*, *Pheretima*, *Polypheretima*]. One or more genital markings may occur.

Female pores: Single (sometimes closely paired?), central within small circular to diamond shaped darker depression on 14.

Spermathecal pores: Four pairs in 5/6/7/8/9 ca. 0.3 circumference apart, (sometimes wholly aborted or posterior pair, at least, rarely lacking; see Remarks below).

Genital markings: Various as small, widely-paired presetal disks with opaque centres in some or all of 6-9, some also nearer spermathecal pores and/or postsetal on 5,6-8; also near male pores. Internally small stalked glands are associated with these markings. However, fully amphimictic specimens may vary in their arrangement of markings. [The Mt Cotton and Taupo specimens both had single markings on segment 8 as figured].

Septa: 3/4-5/6 thin, 6/7-7/8 thickened; 8/9-9/10 aborted (always? – sometimes ventral

rudiments retained of 8/9); 10/11-13/14 with moderate thickening, thereafter thin.

Dorsal blood vessel: Single, continuous onto pharyngeal mass in 4 (sub-oesophageal vessel paired).

Hearts: Small commissural vessels in 5-7 then in 9 and 10; hearts from supra-oesophageal vessel under dorsal vessel in 11, 12 and 13 [?or 10-12, Michaelsen (1892)].

Gizzard: Large, muscular and elongate occupying the space in 7/8-10/11 with proventriculus in 7.

Calciferous glands: Oesophagus appears dilated and vascularised in 11-13 (not calciferous?).

Intestine origin (caeca, typhlosole): In 15 or 16 the intestine widens appreciably (small paired supra-intestinal 'lymph' glands present after 18 dorsally on gut); simple, laterally paired caeca 27-24,23 with margins smooth, or incised (in older specimens? or = *A. divergens*); typhlosole present after 27.

Nephridia: Meroic especially obvious in anterior and around clitellar segments.

Male organs: Testes/funnels in small (paired or unpaired) testis sacs in 10 and 11 attached to the ventral face of the posterior septa (iridescence only occasionally noted); sometimes testis vestigial. Large seminal vesicles fill segments 11 and 12.

Ovaries: Paired in 13 as palmate mass with several egg strings, egg funnels also seen (occasionally infested with *Monocystis sp.*).

Prostates: Often aborted and replaced by small, white spherical cysts of *Monocystis* infestation, although parts of the short bowed ducts may remain. In one specimen only were found small (rudimentary?) racemose glands attached to the ducts. Gates (1972: 178) describes them as in 16-22 with muscular ducts up to 6 mm long and looped; perhaps from his two Taiwan specimens (American Museum of Natural History, 3575) that were supposedly male fertile. The NZ specimen also appeared to be male fertile (cf. *A. clerica* also with prostate glands according to Benham).

Spermathecae: In 6-9 (rarely 6-8, ?or 7-9), ampulla saccular or conical and yellowy on thinner duct, diverticulum with slender stalk and (usually) non-iridescent spherical bulb, reaching as far as axial tip of ampulla; spermathecae often heavily parasitised by *Monocystis*; diverticula sometimes aborted. Segmental allocation of spermathecae may be asymmetrical, e.g. in one specimen examined in current studies the arrangment was thus, 6: pair; 7: rhs, 1, lhs, 2; 8: rhs 2, lhs, 1. Spermathecal ducts free of nephridia.

Gut contents: Usually full of fine soil material.

Notes: Active and multiplying rapidly throughout the year under favourable conditions,

this worm has been reported to wander at night to infest plant beds of plant nurseries (Gates, 1972). These characteristics, along with its regeneration potential, may account for the records of transportation of this worm exceeding those of the peregrine lumbricids. Tropical records are generally rare except from higher altitudes where temperatures are lower. However it may also be restricted by low temperature tolerance and is said to be absent from Scottish greenhouses with a temperature below 15°C and is susceptible to flooding (Gates, 1972:177-180). Sometimes found in association with similar species (with which it may be easily confused), including *Amynthas gracilis*, *A. rodericensis*, and *Metaphire californica* (Kinberg, 1867). Regeneration is mainly of tail segments. Parasites include *Monocystis* gregarines, various other sporozoans, and nematodes (Gates, 1972: 180). Whereas Gates (1972: 19) remarks that parthenogenetic morphs seemingly can support heavier parasite burdens without detriment, it may also be that parthenogenetic sterility is partly a result of such infestations. Barois (1992) discusses the mutualistic microbiology of this species and of *A. gracilis*.

Remarks: Parthenogenesis is implied by the often reduced, parasitised or incomplete male reproductive organs and spermathecae. Gates (1972: 177-180) considered that biparental morphs were rarely (never?) recorded and mentions the various parthenogenetic morphs that have been found. He notes that total loss of spermathecae and male pores is rare, although he found two specimens in a sample of 60 from Kodaikanal, South India that lacked the posterior pair of spermathecae. Such Japanese morphs with spermathecae in 5/6/7/8 (e.g. '*ijimae*' morphs) were also tentatively allowed in synonymy by Easton (1981) (cf. *A. gracilis*, *A. papulosus*). If instead the anterior pair is lacking in some morphs, i.e., spermathecae in 6/7/8/9, then species such as *Amynthas flavescens* may well also be in synonymy, as was suggested by Michaelsen (1900: 264) (see also Blakemore, 2002). Gates (1972: 217) suggested that *P. sheni* may be an athecal morph of either *A. robustus* or *A. diffingens* (= *A. corticis*), but were more likely of the latter.

Separation of species components depends on much greater consideration of types that current resources allow. However, descripitons of *A. diffringens* (as noted below) allow GMs in some of 6-9 and thus, apparently, encompass several latter taxa.

Kinberg's original description of *P. corticis*, in full, is:

"PERICHAETA (Schmarda).

ex parte.

Setae numerosae, anteriores et posteriores numero aequales.

P. corticis *n.* *Setae ubique c. 40:nae, minute aliaeque crescentes majores; segment. 114; longitudo 68 mm. Oahu, sub cortice arborum*"

The last sentence gives the locality as Oahu in Hawaii, under bark of trees [fallen logs?].

Without reason nor any kind of scientific proof, some authors attempt to variously restore random or, worst yet!, nationalistic junior synonyms; hence the need for reexamination of the earliest of synonyms in the account below of "*A. diffringens*".

Amynthas diffringens (Baird, 1869)

– as separated from *A. corticis* by Blakemore (2013)

Fig. Copy of Baird's fig. 1 (a not very informative habitus and seta).

Megascolex (Perichaeta) diffringens Baird, 1869a: 40, fig. 1. [Type locality and habitat: a hothouse nursery at Plas Machynlleth, North Wales. Types in British Museum: BMNH 1869:1:2:1 – consisting of 9 matures and one juvenile with 3 or 4 bits, inspected by RJB 24.IV.2012], ["*Description of a new Species of Earth-worm Megascolex diffringens) found in North Wales*"] & Baird, 1869b: 387 ["*Additonal remarks on the Megascolex diffringens*" – specimens sent from Lady Cullum's hothouse at Hardwick House near Bury St. Edmunds, Suffolk where the gardener says it resided for about 14 years although for 20 years he knew it from Glevering Hall near Woodbridge, Suffolk].

Perichaeta diffringens : Vaillant, 1872: 322. [Caeca present, prostates absent, four pairs of spermathecae but he miscounted the segments (5/6/7/8/9?) as "3/4/5/6/7"].

Pheretima diffringens: Gates, 1934; 1935; 1937: 412, 450; 1939: 430 (syns. *divergens* var. *yunnanensis, divergens, heterochaeta, mirabilis*); 1943: 102 (genital markings on 7-9 midway between furrows and setal arcs, hearts of 10 lacking, prostate glands absent but gential marking glands in 18 are just median to prostatic ducts [cf. description below]); 1959b; 1972: 149, footnote 2: [?syns. (some in part) *californica, campestris, cingulata, clerica, corticis, divergens, heterochaeta, heteropoda, indica, mirabilis, molokaiensis, nipponica, peregrina, perkinsi, sanctae-helenae, silvestrii, tajiroensis, torii, ?carnosa, ?directa, ?homoseta, ?kyamikia, ?morii, ?oyamai, ?pingi*]; Gates, 1972: 177 (syn. *heterochaeta, divergens yunnanensis, mirabilis*); Gates, 1972: 217 (?syn *sheni*); Gates, 1972c: 18,27 (syn. *divergens, heterochaeta, heteropoda, indica, nipponica, oyamai, tajiroensis, ?toriii*); 1982: 44.

Megascolex (*Perichaeta*) *Sanctae-Helenae* Baird, 1873: 96 (corr. *sanctaehelenae*). [From high ground at St Helena, collected by J.C. Melliss, Esq. Type in British Museum: BMNH 1869:6:16:5 – inspected by RJB 24.IV.2012 and found to be juvenile, 40 mm long with 104 segments, damaged by dissection with spermathecae and prostates absent or removed, status: *incertae sedis*]. Baird gives the impression that more than one specimen was found, only one now remains. His description in full:

"Body consisting of about 86 rings, which are more distinct at the two extremities than in the centre. The 11 or 12 rings at each end, have an acute ridge or keel in the centre; those of the middle portion of the body have the keel flattened. The body of the rings is finely striated. Setae short, of a adark colour at the posterior extremity, rather distant from each other. In the centre of the body and at the anterior extremity they appear (in the specimen from which this description was drawn up) retracted, leaving only a mark where they are situated. The first 7 or 8 rings, at the anterior extremity, are strongly rugose or wrinkled. Length from 1 inch and 9 lines to 3 inches. Hab. High ground at St. Helena, J.C. Melliss, Esq."]. [Type locality St Helena. Type: BMNH 1869:6:16:5. Held *incertae sedis* by Michaelsen (1900: 518) with which I now concur (Blakemore, 2014). This taxon usually as a synonym of *A. corticis*].

Original description: Length 4-5 inches (100-125 mm) and "*3 lines in circumferenc*e", with 104-105 segments. Lives in compost, nocturnal wanderer, very active when disturbed and readily breaks into fragments (hence its name). Clitellum from 14. Setae about 60 per segment. Darkly pigmented dorsum and pale ventrum.

Note: First put in synonymy of *A. corticis* (misspelt at "corticus") by Easton (1981: 49) for which he has "*diffringens* Baird, 1869: 40; (syn. *divergens, heterochaeta, heteropoda, indica, nipponica, oyamai, tajaroensis* [sic, lapsus tajiroensis]*, ?torii*) Gates, 1972c: 18"; several other synonyms now probable (see Blakemore, 2002, 2003, 2006, 2010, etc.). Also claimed as "syn. nov." of *corticis* by Easton (1982: 726), it was separated from *A. corticis* by Blakemore (2013).

Amynthas exiguus (Gates, 1930) species-group

INCLUDED SPECIES:

- *Pheretima minuta* Gates, 1929: 18 [non *Amynthas minutus* Beddard, 1900/1 (= *Po.*

polytheca). From Lashio. Types lost].

- *Pheretima exigua* Gates, 1930: 310 (nom. nov. pro. *Pheretima minuta* Gates, 1929 secondary homonym, non Beddard, 1900/1); Gates, 1972: 183-185.
- *Pheretima exigua typica* : Gates, 1932: 512 [Myanmar and Thailand].
- *Pheretima exigua austrina* Gates, 1932: 514 [Myanmar, Thailand and Vietnam. Type Calcutta 3604].
- *Amynthas exiguus exiguus* + *A. exiguus austrina* : Sims & Easton, 1972: 235 [*diffringens* (= *corticis*) group].
- *Pheretima exigua taybacana* Thai, 1985: 616 [from Vietnam].
- *Pheretima exigua chomontis* Thai and Samphon, 1988 [from Laos].
- *Amynthas exiguus aquilonius* Tsai *et al*., 2001: 277 in Tsai C.-F., Shen, and Tsai, S.-C., 2001 [from Mt Hohuan, Taiwan].

Diagnosis: Size 24-75 mm long by 2-3 mm. Four pairs of spermathecal pores in 5/6/7/8/9. Genital markings discs, usually paired, in 7,8-9, in some segments between 17-20 either segmental or intersegmental, and sometimes next to spermathecal pores (glands stalked internally). Spermathecal diverticulum with short to long unlooped stalk to ovoidal seminal chamber. Holandric. Intestinal caeca simple.

Distribution: Subspecies reported from eastern Myanmar, sometimes at elevations up to 1,000m or more; northern Thailand – e.g. Doi Sut(h)ep near Chang Mai at 1,000 feet (300m); Vietnam; Laos (e.g. Thai & Samphon, 1989); and Taiwan sometimes at altitude. Gates thought it was introduced by man into northern regions of Bhamo and Myitkyina (at least) and in Myanmar it was found in both jungle and garden soils.

Remarks: Three of the subspecies are differentiated by Tsai *et al.* (2001 [http://zoolstud.sinica.edu.tw/Journals/40.4/276.pdf], the others from Vietnam and Laos are less well known. Gates (1972: 184) thought parthenogentic morphs were possible and that *P. exigua* was closest to *P. diffringens* (= *Amynthas corticis*), perhaps also to *P. sigillata* Gates, 1936 (= *Amynthas sigillatus* from the Malay peninsula). Cf. also to *Amynthas carnosus* and its recently determined synonym, *A. pingi*.

It was also noted by Gates (1972: 184) that the nominal sub-species sometimes occurs in richly manured gardens and in leaf mould, as well as in lateritic soils and in jungles, thus it may be partially classed as a litter dweller (compost species).

?Amynthas forbesi (Beddard, 1890)

Perichaeta sp. Beddard, 1889: 534.

Perichaeta forbesi Beddard, 1890: 65, Pl. IV, figs. 5-6, Pl. V, fig. 7. [Type locality New Guinea. Holotype in British Museum, 1904:10:5:41 but Beddard mentions two specimens].

?*Perichaeta sp.* Horst, 1893: 318.

Pheretima forbesi: Michaelsen, 1900: 267.

Amynthas forbesi: Sims & Easton, 1972:236 (*martiorum* group).

(The following description is taken from above references).

Diagnosis: '*Pheretima*' with spermathecal pores in 7/8/9. Male pores (in copulatory pouches?) on 18. Genital markings large paired in line with male pores in 17, 19-21. Spermathecae sometimes duplicated. (Intestinal caeca absent?).

Distribution: New Guinea, also possibly introduced to Borneo, Great Bastard Island near Flores, and Indonesia (Michaelsen).

Habitat: ?

Behaviour: ?

Length: 225 mm.

Width: 12 mm.

Segments: ?

Colour: Dark greyish brown, with darker clitellum.

Prostomium: Small (epilobous?).

First dorsal pore: 12/13.

Setae: Numerous, forming complete circles per segment.

Nephropores: Not reported.

Clitellum: Annular 14-½16,16, setae retained (Beddard's figure 5).

Male pores: Widely paired on 18 in copulatory pouches (Beddard's fig. 5, as in figs. 4-5 of *P. biserialis* = *Po. elongata*).

Female pore: Single on 14.

Spermathecal pores: Two pairs in 7/8/9 ca. 0.3 circumference apart.

Genital markings: Large paired in line with male pores presetally in 17, 19-21.

Septa: 7/8 thick, 8/9/10 aborted, 10/11/12 thick.

Dorsal blood vessel: ?

Hearts: ?

Gizzard: In 8-10 (Beddard's figure 5).

Calciferous glands : ?

Intestine origin (caeca, typhlosole): caeca simple (presumably in 27 - Sims & Easton, 1972: 193).

Nephridia: Meroic.

Male organs: Testes/funnels (in 10 and 11 parasitized by gregarines in sacs?); seminal vesicles large in 12 only (metandric?).

Ovaries: In 13; ovisacs in 14.

Prostates: (Racemose?).

Spermathecae: Paired in 8 and 9 but duplicated in either 8 or 9 on one side (i.e., polythecate?); ampulla pear-shaped, single small diverticulum.

Gut contents: ?

Remarks: *Amynthas forbesi* was one of the species selected by Sims & Easton (1972) for their numerical study, and they must have inspected the holotype. However, the male pores were originally figured in copulatory pouches, in which case this taxon does not belong in *Amynthas*. Possibly it is in *Metaphire* in which case it compared to *M. malayana* or, if there are shown to be nephridia on the spermathecal ducts, it would belong in *Pheretima*. Its intestinal caeca were stated to be simple (Sims & Easton, 1972:193, Section IIId); were they absent then it would comply with *Metapheretima* [cf. *Me. pallens* (Ude, 1932) from PNG] or *Polypheretima* [cf. *Po. elberti* (Ude, 1932) from Lombok], especially since Beddard had compared it with *Polypheretima biserialis*. The only other listed member of the *mortiorum*-group was *Amynthas mortiorum* (Michaelsen, 1938: 175) that is particularly unusual in having numerous setae (c. 450 on segment 7) arranged in two or three rows on segments 2-9 (Easton, 1984: 716), that possibly qualify it for inclusion in *Planapheretima*.

Amynthas glabrus (Gates, 1932)

Pheretima glabra Gates, 1932: 395; Gates, 1972: 187 (syn. *tenellula*, *vieta*). [From Nam Hpen Noi, Yunnan (in China on border with Myanmar). Types missing].

Pheretima tenellula Gates, 1932: 398. [From Kwang Yeh, Yunnan and Myanmar. No types]. [Misspelt as "tennellulus" in Sims & Easton (1972: 246) who also (1972: 213, 237) have these taxa in an "*Amynthas youngi*-group" erroneously since *A. youngi* (Gates, 1932) actually has two pairs of spermathecae *dorsally* in segment 6 and in 6/7].

Pheretima vieta Gates, 1936: 462. [From Peng Sai, Myanmar. Types none].

(*Pheretima papilio* : Ohfuchi, 1956: 140 [non Gates, 1930: 316])? [Misidentification].

Amynthas glabrus : Sims & Easton, 1972: 242; Easton, 1981: 50 (syn. *vieta*, ?*papilio*: Ohfuchi, 1956).

Diagnosis: Spermathecal pores small, paired postsetally on 6 between equator and 6/7 (or absent in some morphs). Male pores superficial on 18 within logitudinal seminal grooves in 17-18 or extending further. Genital markings absent. Intestinal caeca, small, simple.

Distribution: Yunnan (China) and Myanmar (Gates, 1972: 188), Japan: Kyushu and Ryukyu Islands (Easton, 1981: 50), also reported from Sichuan and Guizhou Provinces of China (by Zhong *et al.*, 1987), and from Vietnam. Not yet confirmed from Taiwan.

Remarks: Gates (1972: 187-188) described this species as parthenogenetic with several known morphs. Gates (1972: 205) rejects the identification by Ohfuchi (1956: 140) of Iriomote, Ryukyu specimens with his *Pheretima papilio* Gates, 1930 subspecies, and Easton (1981) and Chen & Chuang (2003) places these misidentified specimens in possible synonymy with *A. glabrus* pending further investigation. Huang et al. (2007) say: "*Gates named three species, Pheretima tenellula (Gates, 1932), Pheretima glabra (Gates, 1932) and Pheretima vieta (Gates, 1936). Then he combined the three species into one species in 1972, Pheretima glabra (Gates, 1932), though they were largely different in morphological characters, especially with or without spermathecal pores, the position of papillae in male pores. We examined many specimens from Yunnan Province of China by morphological characters, and some of them were wholly identical with Amynthas tenellulus. So we redivided the species into three species, Amynthas tenellulus, Amynthas glabrus and Amynthas vieta.*" But parthenogentic morphs may be one species.

The Japanese reports seemingly refer to another taxon requiring resolution, even though as recently as 2010, an online report is from Fukuoka-ken, Kyushu by Y. Sugi (sky.geocities.jp/yasuakisugi1221/WormTaxonomy/4AmyMetaAll.pdf September 2017).

?Amynthas godeffroyi Michaelsen, 1899

Amyntas godefroyi (corr. *godeffroyi*) Michaelsen, 1899: 17. [Type locality Viti, Fiji. Types missing (Reynolds & Cook, 1976: 107)].

Pheretima godeffroyi: Michaelsen, 1900: 268.

"*P. godefroyi* (Michaelsen, 1907)": [sic, lapsus] Gates, 1982: 37.

Pithemera godeffroyi (part?): Easton, 1984: 119 (syn. *Pheretima sedgwicki ablata* Ude, 1905).

Pithemera godeffroyi: Sims & Easton, 1972: 232; Lee, 1981: 564, [Lee rejected synonymy of Ude's species in *godeffroyi*, cf. Easton (1984)].

Taxonomic note: Description from Michaelsen (1899) where he spelt it "godefroyi" and Michaelsen (1900) were he corrected it to "goddefroyi".

Diagnosis: *Amynthas* with two pairs of spermathecae in 6/7/8. Male pores on 18 (without copulatory pouch). Markings paired posteriorly in 16 and 17 in line with male pores. Intestinal caeca moderately large [paired in 27, or, (Gates, 1982) single, ventromedian from egion of 22-23].

Distribution: "*Viti*" = Fiji (and doubtfully Samoa?).

Behaviour: ?

Length: 105 mm.

Width: ca. 3 mm.

Segments: 95.

Colour: ?

Prostomium: ?

First dorsal pore: 12/13.

Setae: Numerous, ca. 27-48; ventral setae sometimes enlarged on segments 4-8.

Nephropores: None.

Clitellum: Annular: ½14-½16; setae on 16 present, on 14 more ventral.

Male pores: On 18 ca. 0.3 circumference apart.

Female pore: Median on 14.

Spermathecal pores: Two pairs in 6/7/8 ca. 0.5 circumference apart.

Genital markings: Paired papillae on posterior of 16 and 17 in line with male pores.

Septa: 6/7,10/11 and 11/12 thickened, 7/8 and 9/10 thin, 8/9 aborted.

Dorsal blood vessel: ?

Hearts: ?

Gizzard: In 8.

Calciferous glands : ?

Intestine origin (caeca, typhlosole): ? Simple, caeca moderately large (paired in 27?, or single, ventromedian from region of 22-23). [Michaelsen's (1900: 269) description of *P. godeffroyi* has "*Darmblindsäcke einfach, mässig gross*" (Intestinal caece simple, moderately large)].

Nephridia: Meroic.

Male organs: Testes/funnels holandric(?), seminal vesicles large paired in 11 and 12.

Ovaries: In 13.

Prostates: With large racemose gland duct to male pores without copulaory pouch.

Spermathecae: (Paired in 7 and 8); oval ampulla half as thick and a third as long as duct, with diverticulum as long as the duct.

Gut contents: ?

Remarks: Ude (1932) combined *Pithemera ablata* (Beddard, 1892), from Samoa, Tonga and Vanuatu, with *P. godeffroyi* (Michaelsen, 1899) as did Easton (1984:119). *Pithemera* requires intestinal caeca originating near 22. However, Lee (1981: 564) stated that the orginal description of *godeffroyi* had a large pair of caeca from 27 which (if so) requires maintaining *Amynthas godeffroyi* and *Pithemera s. ablata* independently as herein. [See descriptions below of *Pithemera sedgwicki* and *Pithemera ablata*].

Amynthas gracilis (Kinberg, 1867)

Fig. 2.6 *Amynthas gracilis*, Brookfield specimen (a) ventral view, (b) prostate with genital marking glands near ectal end of duct, (c) spermathecae, (d) prostomium with attacking ant covered in mucus, (e) intestinal caeca dorsal view.

Fig. 2.7 *Amynthas gracilis* specimen, ventral view with spermathecae (iterated) and prostate *in situ*; prostomium dorsal view.

Nitocris gracilis Kinberg, 1867: 102. [Type locality Rio de Janeiro. Types in Stockholm Museum, 1944 (Reynolds & Cook, 1976: 108), immatures (Sims & Easton, 1972: 214)].

?[*Perichaeta bournei* Rosa, 1890: 110 from Karen Hills, Myanmar (and Vietnam)].

Perichaeta hawayana Rosa, 1891: 396, figs. 7, 9 (of prostate and spermatheca). [Type locality Hawaii. Type in Vienna]. [Redescribed by Beddard, 1896: 201 as being almost identical to *Pe. bermudensis*].

?*Perichaeta ijimae* Rosa, 1891: 402. [Type locality Japan. Types in Vienna]. [Spermathecae 5/6/7/8 lacking diverticula].

Perichaeta bermudensis Beddard, 1892a: 160. [Thirty or forty spirit specimens from Surgeon-Major Windle of Bermuda (not from Kew Gardens). Syntypes British Museum: 1904:10.5.1362-65 (these inspected by Sims & Easton, 1972: 180 put in an *hawayana*-group and checked by RJB on VI.2013. Labels "*Perichaeta*

bermudensis Beddard 1892 Types 1904:10.5.1362/65 Loc. Bermuda Beddard Coll Ref. Proc. Zool. Soc. Lond. 1892 p.160", "*Perichaeta hawayana 1904:10:5:1362-65*", "*Types of Perichaeta bermudensis*". Jar contains many specimens, several found to be dissected, possibly of two or three different species, most look more like *A. corticis*); Beddard, 1896: 208 (specimens from Hong Kong); 1900: 410 he again confused description of *bermudensis* by saying "*Spermathecae two pairs in VI, VII, VIII*"!]. [Non *Pontodrilus bermudensis* Beddard, 1891].

Perichaeta barbadensis (part., spec "b"?) Beddard, 1892a: 167. [Types British Museum 1904:10.5.11-13 inspected by RJB VI.2013 cf. *A. morrisi*]. [With spermathcal pores in 5/6/7/8 and shown in fig. 6 that is said by Beddard (p. 167) to be specimen "a", but is actually specimen "b"; cf. *Amynthas morrisi*].

?Perichaeta mauritiana Beddard, 1892a: 170, Pl X, figs. 5-6 [From Kew originating in Mauritius. Types in British Museum 1904:10:5:203-5 (the numbers suggest three specimens although the original one was misplaced by Beddard, 1900a: 425 and these specimens were not inspected by RJB). [Described with two pairs of spermathecae in 7 & 8 and genital markings median to male pores; cf. *A. morrisi*]; ?Beddard, 1900a: 425 (he described possibly different taxon?).

Perichaeta mandhorensis Michaelsen, 1892: 241, figs. 18-19. [From Burma, Mandhor, Java. Types Humboldt Museum, Berlin: 484. Note: Gates (1972: 217) remarks that Beddard's British Museum specimen 1904:10.5.1401 labeled *P. mandhorensis* from West Indies is a misidentification of *Amynthas robustus*].

?Perichaeta kamakurensis Goto & Hatai, 1898: 68. [Types?].

?*Perichaeta parvula* Goto & Hatai, 1898: 68. [Types?]. [Non Ohfuchi, 1956 (= *Metaphire parvula*)].

?*Perichaeta decimpapillata* Goto & Hatai, 1898: 71. [Types?]. [Name restored (ICZN Article 33.5) from Michaelsen's (1900: 314) unjustified emendation to "*decempapillata*"].

Amyntas ijimae : Beddard (1900: 635) (syns. *kamakurensis, parvula*, *decimpapillata*).

Pheretima hawayana : Michaelsen, 1900: 271, 316 [syn. *aspergillum* : Beddard, 1888 (non Perrier, 1872), *bermudensis*, ?*mauritiana*]; Stephenson, 1923: 300 (?syn. *cupulifera*, *barbadensis*, *pallida* but possibly confused with *A. morrisi*); Gates, 1932: 435-438 (gives extensive history to that date of the synonymies); Gates, 1937: 354 (syn. *aspergillum, bermudensis*); Gates, 1939: 445; 1972: 189, 217

[syn. ?*barbadensis* (part), *mandhorensis*, ?*mauritiana*]; 1982: 47. *P. hawayana* as listed by Stephenson (1932) and Gates (1935) is believed to actually refer to *A. morrisi*.

Amyntas hawayanus : Beddard, 1900a: 645 (syns. *pallida, mandhorensis, bermudensis, morrisi, barbadensis, mauritiana, amazonica, sanctijacobi, carnosa, insulae, cupulifera*), cf. Beddard, 1900b: 420 [syns. *bermudensis, barbadensis, morrisi* : Beddard, 1892: 166 (but this is possibly the *gracilis* component of his confused *morrisi* description – see my notes on this subject below), *mauritiana, mandhorensis, pallida, amazonica, cupulifera*].

?*Pheretima kagoshimensis* Takahashi, 1932: 343. From Japan.

?[*Pheretima kamitai* Kobayashi, 1934: 5, fig. 4-6. From Korea is similar but lacks GMs and is usually placed under *Amynthas phaselus*].

?*Pheretima hawayana* var. *barbadensis* : Cernosvitov, 1934: 49 [probably mistakenly listed as a separate taxon by Reynolds & Cook (1976: 75)].

Amynthas gracilis : Sims & Easton, 1972: 235 (in an *A. hawayanus* group containing nearly 50 nominal taxa); Easton, 1981: 50 (syn. *hawayana, ?kamakurensis, ?parvula, decimpapillata, ?carnosa, ?kagoshimensis*); Easton, 1982: 728 (syn. *hawayana*); Sims & Gerard, 1985: 130 (syn. *hawayana*); Blakemore, 2002, 2008, 2010.

[*Amynthas kaoshihfoensis* James *et al.*, 2004, MS syn. prevented by Blakemore, 2004].

?*Amynthas shinanmontis* Tsai and Shen, 2007. **Syn. nov.** [Yet another speculative parthenogen from Taiwan, claimed similar to *A. gracilis* but actually possibly one of any of a dozen or more degraded morphs from Japan/Korea/China].

?[*Amynthas bouchei*, *Amynthas omodeoi* and *Amynthas edwardsi* all by Zhao & Qiu in Zhao, Sun & Qiu, 2009 are possible **syns. novae** from China].

?[*Amynthas xamtaiensis*, *Amynthas vanhyai* both poorly described by Hong (2017) **syns. novae** from Laos: yet more names pointlessly added with no effort to resolve prior synonyms (listed above in order) and yet again with figures that have the segments miscounted and the spermathecae misdescribed, also lacking images of the caeca, etc. Ironically the report of *A. gracilis* in the same paper seems to refer to some other taxon, possibly the supposedly "new" *A. multipapillatus* is no different to *A. papulosus*! No attempt was made to provide DNA support and it is seemingly left to others to sort out this mess].

Taxonomic Note: *Amynthas carnosus* (Goto & Hatai, 1899) is removed from synonymy

(see Blakemore, 2012).

Diagnosis: *Amynthas* with three pairs of spermathecal pores, ca. 0.25-0.3 of the body circumference apart in furrows 5/6/7/8 (rarely only two pairs). Intestinal caeca simple with incised margins (always?). Genital markings median to male pores (and near spermathecal pores). [Cf. *A. papulosus* that differs mainly in elongate diverticula bulb and genital markings, and cf. *A. corticis* morphs with only three pairs of spermathecae].

Distribution: From tropical and warm temperate localities on most continents, e.g. in Sao Paulo, Brazil it is the commonest species in gardens (Gates, 1972: 190). Sims & Gerard (1985: 130) give reports from High altitudes in Pakistan, India, Bangladesh, Sri Lanka, Burma, Thailand and southern China (its homeland?) plus quote from a "Greenhouse, England" by Gates (1972). Gates in addition to these gives Singapore, Kuala Lumpur, Taiwan, Borneo, Java, Samoa, Tahiti, Fiji, as well as Hawaii. Plus USA, Mexico, Guatemala, Salvador, Bermuda, Barbados, Gruench Guiana, Brazil, Uraguay, Argentina and Chile. For England, France, Poland and Russia Gates notes it only in Greenhouses, plus he gives Madeira, Egypt and St Helena. Ascension Island Gates, (1969). It is widespread in Colombia (Feijoo *et al.*, 2004), the most numerous in Hawaii and is also found in New Guinea (Nakamura, 1992) and Australia (Easton, 1984). Brown & Fragoso (2007) record it from also Cuba, Panama and Venezuela. Rarely reported from northern Europe, e.g. from Denmark on Skov-og Naturstyrelsen database on introduced taxa www.skovognatur.dk/natur/invasive_arter/images/introarter.xls Jan., 2007]. Original home in China? Easton (1981: 50) summarized reports from Japan/Okinawa and Easton (1984: 118) from Pacific including Raoul Island, NZ. For Australia, it had been previously recorded from Mundubbera and around Brisbane in Qld and from the NT (Easton, 1982); other records are from the author's studies as noted "Locality" below. *A gracilis* has usually been reported under the name of its junior synonym *P. hawayana* (Rosa, 1891).

Locality: Samford, Brookfield, Mt Cotton, Rockhampton, Mackay, Toowoomba, Qld; Alstonville, NSW; also Rarotonga, Cook Islands, and most recently from Jeju, Korea - new records.

Habitat: Under pasture beside cattleyard drain, riverbank under litter Samford; on road surface Brookfield; in gardens Rockhampton; "*ex compost Mackay, Qld*"; in farm and garden soils.

Behaviour: Typical lashing behaviour when disturbed, yellow coelomic fluid ejected and occasional autotomy of posterior segments.

Length: 56-156 mm.

Width: 4-5 mm.

Segments: 71-98.

Colour: Varies, dark brownish yellow dorsum; ventrum paler; clitellum biscuit.

Prostomium: Open epilobous often everted on preservation.

First dorsal pore: 9/10? or 10/11, faint on clitellum.

Setae: Numerous 40-50 per segment, ventral series sometimes enlarged in 2-9; sometimes setae partly visible on clitellum.

Nephropores: None.

Clitellum: Annular usually most of 14-16.

Male pores: 0.24-0.3 diameter apart on depressed corny pads, equatorial and sunk in 18, lateral to one or more pairs of small markings.

Female pores: Single, central within small circular depression on 14.

Spermathecal pores: Three pairs in 5/6/7/8 ca. 0.3 diameter apart (rarely two pairs in 6/7/8 or, doubtfully, in 5/6/7).

Genital markings: In 18 median to male porophores various small discs (associated stalked glands internally), occasionally on 17 and 19 too; sometimes small postsetal pairs in some or all of 6-9. [Note: *A. kamitai* (Kobayashi, 1934: 5, fig. 4-6) from Korea is similar but lacks GMs].

Septa: 5/6/7/8 thicker, 8/9/10 aborted.

Dorsal blood vessel: Single, continuous onto pharynx.

Hearts: Small 6-7 and 9, large 10-13.

Gizzard: Large, muscular, spherical in 8.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): 14 or 15; laterally paired caeca simple but with several short lobes on edges, 27-25,24.

Nephridia: Meroic.

Male organs: Testes/funnels paired in testis sacs in 10 and 11; seminal vesicles (9), 11 and 12.

Ovaries: Paired in 13 palmate mass with several egg strings.

Prostates: Large racemose in filling 14-19 or 14-24 with long muscular ducts and genital marking glands near ectal end.

Spermathecae: Large saccular ampullae with tapering ducts from base of which a thin diverticular stalk branches each with a small, slightly iridescent terminal bulb.

Gut contents: Fine soil (geophagous: Gates, 1972).

Notes: *A gracilis* has usually been reported under the name of its junior synonym *A. hawayanus* (Rosa, 1891) in North America and is given common names such as "Pheretimas" or "Alabama Jumper", "Georgia Jumper", etc. This species is similar to, and may easily be confused with, *A. corticis* but it has only three pairs of spermathecae, is found less frequently than *A. corticis* and, in association with other *Amynthas spp*. It is stated to be geophagous by Gates (1972). Reproduction is presumably bi-parental (cf. *corticis*). Regeneration of first four head segments is possible, tail regenerations are common; parasites include ciliates, sporozoans, nematodes, unidentified cysticercoids and an insect (Gates, 1972).

Remarks: Stephenson (1923) included quadrithecal morphs in "*P. hawayana*" (?syn. *barbadensis*, *pallida*), which may, or may not, be referrable to *Amynthas morrisi*. It seems Beddard's confused description of *Perichaeta barbadensis* involved more than one species and that his specimen "b", with three pairs of spermathecae belongs in *A. gracilis*, while the remainder possibly belongs in *A. morrisi* (?or some other taxon – see Gates, 1939: 430 and **Remarks** below). Beddard's *mauritiana* was thought by Michaelsen (1900: 316) and Gates (1972: 217) to belong to *hawayana* (= *gracilis*), or *barbadensis*, or *robustus*; while Sims & Gerard (1985: 132) mistakenly have both *barbadensis* and *mauritiana* in *morrisi*. Recent revision has restricted *barbadensis* as a junior synonym of *gracilis* (by Blakemore, in prep. 2014). Because of its markings around the male pores, *mauritiana* is also though to be a possible morph of *A. gracilis* lacking the anterior pair of spermathecae which are in 6/7/8 NOT 5/6/7 as in *morrisi*.

Easton (1981) tentatively included *carnosa* as a synonym of *gracilis*, whereas Gates (1972) thought it possibly in *diffringens* (= *corticis*); however it was maintained as a separate species by Blakemore (2003) as the genital markings were described as closely paired (see separate description herein).

Sims & Easton (1972: 176, 214) remark that *gracilis* was the type-species of the monotypic genus *Nitocris*, a pre-occupied name, but the precise identity of the type-series cannot be established as the specimens are immature. They nevertheless accepted *gracilis* as a priority species of an *Amynthas hawayanus* group, and subsequent authors have been obliged to concur. DNA data could help solve that issue and open the proverbial Can O' Worms (Blakemore, in prep.).

Kinberg's original description, in full, was:

"N. gracilis *n. Lobus cephalicus longitudinem partis mediae superioris segmenti*

buccalis aequans; segmenta 89-91; longitudo 42-66 mm. Rio de Janeiro, in horto botanico."

Amynthas hendersonianus hendersonianus (Cognetti, 1914)

Pheretima hendersoniana Cognetti, 1914a: 255. [From Henderson Isl. (formerly Elizabeth Island) in the Pitcairn group of the South Pacific. Types BM 1913:12:13:1-2].

Diagnosis: Length 80-108 mm x 4.5-6 mm wide; segments 120; Setae 32-70; dorsal pores from 12/13; no setae between male pores about 0.14 C apart on 18; papillae paired on (8), 19 and 20, 21 postsetally and close to mid ventral line, spermathecal pores 7/8/9; caeca simple in 26; last hearts 13; holandric; spermathecae with simple diverticula and glandular mass on either side of exit internally. Found with *Pheretima* (*Ph.*) *montana arthuri* (Benham, 1897) a synonym of *Pheretima montana* Kinberg, 1867.

Distribution: Reported, possibly as an introduced species, from the remote British protectorate UNESCO World Heritage Site of Henderson Island in South Pacific in Pitcairn group. These islands were populated in prehistoric times by Polynesians peoples.

Notes: Sims & Easton (1972) put it in *Amynthas aeruginosus* spp-group with its other subspecies from Papua New Guinea, the probable origin of this taxon.

Amynthas hupeiensis (Michaelsen, 1895)

Fig. 2.7.1 *Amynthas hupeiensis* from Watarase, Japan specimen showing ventral view, spermathecae, intestinal caeca and prostates; plus dorsal view of prostomium.

Perichaeta hupeiensis Michaelsen, 1895: 35, fig. 11-12. [Type locality Shi-hui-yao by Wuchang in the provence of Hupei (= Fuchow), China; Hamburg types missing although Gates 1937, 1939: 445) inspected hamburg V9086 this was not the "*original*"].

Amyntas hupeiensis: Michaelsen, 1899: 6. [From Central Japan (Nakahama)].

Pheretima hupeiensis: Michaelsen, 1900: 273; Chen, 1933: 251, fig. 19; Kobayashi, 1936; 1938: 152; Grant, 1955: 49; Gates, 1937: 356; 1939: 448; 1958; 1972: 213; 1982: 52.

Amynthas hupeiensis: Sims & Easton, 1972: 237; Easton, 1981: 36, 53 [where name is misspelt as "*hupiensis*"]; Blakemore, 2002; 2003; 2008; Chang *et al.*, 2009: 50,

fig. 21.

Diagnosis: Green colouration, coiled body. *Amynthas* with paired spermathecal pores ca. 0.16 circumference apart in 6/7/8/9 [Michaelsen (1900: 273) was emphatic that there were three rather than two pairs of spermathecal pores]. Male pores superficial on small porophores on 18. Genital markings large paired approximately in line with male pores in 17/18 and 18/19 (sometimes just median to line of male pores). Intestinal caeca simple from 27. Septa 8/9/10 retained and thickened. Spermathecal diverticula long.

Distribution: China, Taiwan, Vietnam, Korea, Japan - from Hokkaido to Okinawa (e.g. Michaelsen, 1899; 1900; Easton, 1981, pers. obs.) and introduced into North America (first reported from Washington, D.C. in 1910 and since spread to other States e.g. University of Pennsylvania campus, Philadelphia, and Champaign County, Illinois - see reports by Chen, 1933; Gates, 1937; 1958; Grant, 1955; Edwards & Lofty, 1977: 63; Zaborski & Gittenger, 2001 see also http://www.inhs.uiuc.edu/cee/reports/bioecology.html), also New Zealand (e.g., Easton, 1981: 53), and Torres Strait islands, Australia (recorded by ?). Reports of *Metaphire posthuma* from Egypt, Bahamas, Argentina, and France require confirmation as *A. hupeiensis* has been confused with *Metaphire posthuma* in the past (Gates, 1972: 213). A recent (unconfirmed) report is of *A. hupeiensis* from Mexico (Brown & Fragoso, 2007).

Locality: Current specimens from copper contaminated and control sites at Watarase in Tochigi ken, Japan collected 2003 by Dr Takafumi Kamitani; also from (芹が谷公園, 東京都町田市原町) park at Hara-cho, just east of Machida station collected by RJB and Yuko Hiramoto (6th Sept, 2004); specimens from rice fields in Hikone, Lake Biwa (collected 19.VI.2009 by RJB) in LBM collection. Also commonly found in Korea, often in or near rice fields (pers. obs.). 12th June, 2013 collected from Rodale Institute, Pennsylvania from Shumei plots (RJB with Elaine Ingham's help).

Habitat: Mostly inhabiting cultivated sandy soils (Chen, 1933: 255). Reported as a pest of courses by Shread (1950) - http://turf.lib.msu.edu/1950s/1950/500432.pdf.

Behaviour: "*We can easily recognize their presence by their castings which are very slender and elevated. Immediately upon the removal from the earth, the worm will instantly coil itself into a round convolution and remain motionless for a long while. This characteristic behavior will easily help us to identify the worm in the field. Again it has a peculiar and unpleasant odor which is familiar to most laymen*" (Chen, 1933: 255). Specimens collected in current studies also showed this flaccid coiling behaviour which

was distinct and quite different to other pheretimoids that tend to lash their bodies vigorously or 'snake' away from any disturbance. The smell is also distinctive.

Length: 40-222 mm; e.g. 40-55 (Michaelsen), or 150 mm or more; range 70-222 (Chen, 1933); current specimens around 100 mm.

Width: 3-6 mm.

Segments: 97-138; current specimens about 130.

Colour: Grey-gold (Michaelsen – perhaps for preserved specimens) or light grass green dorsally and pale grey ventrally with milky or light chocolate clitellum (Chen). Current specimens are either a pale green copper coulour, or a darker brown in preservative with slightly darker mid-dorsal line and brown clitellum. Some (filtered?) photos show specimens as more vivid green.

Prostomium: Epilobous; tending to pro-epilobous in current specimens.

First dorsal pore: 11/12/13; small.

Setae: Fine and numerous, usually 70-132 per segment; about 80 or more in current specimens with ventral setae larger and darker.

Nephropores: Not reported nor found (meroic).

Clitellum: Annular 14-16, setae visible; appearing to encroach into 13 in some current specimens.

Male pores: Ca. 0.16 circumference (or about 2mm) apart on small papillae on 18.

Female pores: Single on 14.

Spermathecal pores: Three pairs in 6/7/8/9 (not two pairs!) just less than the line of the male pores.

Genital markings: Large paired discs just median to the male pore lines in 17/18 and 18/19. Corresponding genital glands internally are roundish and compact; but sometimes glands obscure (as in current specimens).

Septa: 5/6-7/8 strong, 8/9/10 retained and strengthened, thereafter 10/11/12/13 only slightly thickened. [However, I have a LBM specimen which appears to lack 8/9 completely as spermathecae in 8 and 9 are in the same undivided section!].

Dorsal blood vessel: Single.

Hearts: Stout in 10-13.

Gizzard: In 8, muscular (also reported in 9 but in 8 in current specimens).

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): 15 or 16 (16 in current specimens); caeca "*einfach, zipfelförmige etwas eingeschnürt*" (i.e., simple, conical and a little constricted) in 27-24.

From 16-23 a slight dorsal ridge is present but from 27 a deep lamellar typhlosole develops (Gates, 1958 and seen in current specimens).

Nephridia: Meroic; numerous on body wall and septa.

Male organs: Testes/funnels in 10 and 11 in sacs (not irridescent in curren specimens); seminal vesicles large in 11 and 12; (empty pseudovesicles may be present in 13).

Ovaries: In 13; ovisacs not seen.

Prostates: Racemose glands in 17-19, duct muscular, coiled.

Spermathecae: Three small pairs in 7-9, ampulla saccular not well marked from duct, with twisted, tubular diverticulum at least twice as long as the ampulla, sometimes five or more times as long. Filled with iridescent material in current specimens.

Gut contents: Mainly soil with grits and only coarse organic debris.

Remarks: *Amynthas hupeiensis* is distinguished from the similar *Metaphire bahli* and *M. peguana* by its superficial male pores. Gates (1972: 213) says that the Chinese species, *Amynthas hupeiensis*, has in the past been mistaken for *Metaphire posthuma* (that has 4 pairs of spermathecae in 5/6/7/8/9 and GMs equatorial in 17 and 19, at least); thus some reports may be questionable. The retention of septa 8/9/10 had seemed a good character (cf. LBM specimen noted above!) although the deep green colour, odour, and coiled behaviour are also distinctive.

Watanabe (1975) reports on casting activity of this species.

[**Start of *A. illotus* spp-group**].

***Amynthas illotus* species-group** *sensu* Sims & Easton (1972).

Amynthas illotus species-group Sims & Easton, 1972: 236 ["*included names*": *A. ambiguus* (Cognetti, 1906: 782) now part of *Metaphire hilgendorfi* species-complex from Japan (non *Pheretima barbara ambigua* Cognetti, 1913: 302 (= *Pheretima* (*Parapheretima*) *barbigua* Blakemore, 2004 nom. nov.); *A. assacceus* (Chen, 1938) from Hainan [syn. *A. medipusilla* (Nakamura, 1999) nom. nov. pro *Pheretima pusilla* Ohfuchi, 1956 (non Ude, 1893 = *A. minimus*), ?*Amynthas proasacceus* (sic) Tsai et. al., 2001], from Hainan, Taiwan, Ryukyus; *A. illotus* (Gates, 1932); *A. irregularis* (Goto & Hatai, 1899) [non *Perichaeta irregularis* Spencer, 1895: 288 (= *Perionychella irregularis*)], a junior synonym of *Metaphire hilgendorfi* from Japan; *A. pusillus* (Ohfuchi, 1956) [non Ude, 1893 (= *Amynthas minimus*)] from

Sakishima, Ryukyu Islands renamed *A. medipusilla* (Nakamura, 1999) and now a junior synonym of *A. assacceus*; *A. sheni* (Chen, 1935) from Hong Kong, a degraded morph of either *A. robustus* or *A. corticis* - most probably the latter; and *A. varians* (Chen, 1938) (part - but not the type that has spermathecae in 5/6 or 5/6/7 in this hodge-podge conglomerate taxon)];

Amynthas illotus group; Easton, 1981: 53 [included Japanese names: '*illota*': Ohfuchi, 1956: 136, (non Gates, 1932: 397); *A. pusilla* Ohfuchi, 1956 (non Ude, 1893) now renamed *A. medipusilla* (Nakamura, 1999) and a synonym of *A. assacceus* (Chen, 1938); '*Pheretima*' *oyuensis* Ohfuchi, 1937];

Amynthas illotus group; Tsai *et al*., 2002 [included species: *Amynthas hohuanmontis* Tsai *et al.*, 2001: 276 (nomen nudum until published in 2002: 757) from Taiwan; *A. illotus* (Gates, 1934); *A. assacceus* (Chen, 1938); *A. sheni* (Chen, 1935); *A. oyuensis* (Ohfuchi, 1937). But these latter authors overlooked inclusion of their own *A. catenus* Tsai *et al*., 2001 from Taiwan (the holotype and paratypes of which lacked spermathecae although other specimens apparently had up to three pairs) and all seem to have overlooked *Perichaeta atheca* Rosa, 1896 from Sumatra that was listed as *species incertae sedis* in Sims & Easton (1972: 223) where they note its copulatory pouches place it "*either in* Metaphire *or* Pheretima *(*Pheretima*)*", Michaelsen (1928: 41) regarded it as a subspecies of *indica* (cf. *Ph. darnleiensis*). Also overlooked is *Amynthas defectus* (Gates, 1930) (syn. *jacita* Gates, 1932) from Myanmar that has complex, manicate caeca and up to three pairs of spermathecae in 5/6/7/8 with morphs lacking spermathecae and/or prostates (cf. *M. hilgendorfi / A. tokioensis* group); and *A. infantalis* (Chen, 1938: 392) from Hainan that either has a single pair of spermthecae in 6 or, more usually, they are absent.].

Diagnosis: Spermathecal pores absent (at least in holotypes?) i.e., athecate parthenogenetic morphs. Male pores superficial (or pouched in *P. atheca* or absent?). No genital markings. Intestinal caeca simple [or manicate in Sims & Easton's account of *A. ambiguus* (Cognetti, 1906: 782) and in *A. defectus* (Gates, 1930) both now part of *Metaphire hilgendorfi*/*A. tokioensis* species-complex]. Gates' original two *illotus* specimens were 150-160 by 5-6 mm size with 120 segments; Ohfuchi's specimens were 125-155 mm with 125-144 segments; *A. assacceus* is in the size range 30-80 mm long with ca. 69-90 segments; and '*Pheretima*' *oyuensis* is about 50-55 mm with 75-93 segments.

Distribution: (Most of these parthenogenetic events have no particular biogeographic nor phylogenetic merit). Reported from Myanmar, Hainan, China (Yunnan, Hong Kong), Taiwan, Ryukyus, Japan, Korea.

Species names currently included in *A. illotus* species group:

1/. ***Amynthas assacceus*** (Chen, 1938)

Pheretima assacceus Chen, 1938: 382. [Two specimens from Hainan Island. Types?]. [Note: name sometimes misspelt "asacceus"].

Amynthas assacceus : Sims & Easton, 1972: 236; [*Amynthas asacceus* lapsus] : Tsai *et al.*, 2001: 284; 2002: 761 [syn. *pusilla* Ohfuchi, 1956 (non Ude)]; Blakemore, 2003 [syn. *P. medipusilla* Nakamura, 1999: 2 nom. nov. pro *Pheretima pusilla* Ohfuchi, 1956 (non Ude, 1893 = *A. minimus*)].

?*Amynthas proasacceus* (sic) Tsai et. al., 2001: 282. [Taiwan. Types in Taiwan].

Distribution: Hainan, Taiwan, Ryukyus.

Remarks: Nakamura (1999: 2, 20) proposed the replacement name "*Pheretima medipusilla*" for the name cited in Easton (1981: 54) as *Amynthas pusillus* (Ohfuchi, 1956). The specimens described as *A. proasacceus* were thought by Tsai et al. (2001: 285) to be closely related to the ancestral forms of *A. assacceus* and were consequently placed in provisional synonymy of this prior taxon by Blakemore (2003).

2/. ***Amynthas catenus*** Tsai *et al.*, 2001: 276, 279. [Taiwan. Types in Taiwan]. Remarks: Spermathecae absent (holotype), or in some or all of segments 6-8; length = 60-106 mm.genital markings mid-ventral.

3/. ***Amynthas hohuanmontis*** , Tsai et al., 2002: 757 [*nomen nudum* in Tsai *et al.* (2001: 276) validated by subsequent publication]. [Taiwan. Types in Taiwan].

4/. ***Amynthas illotus*** (Gates, 1932).

Pheretima illota Gates, 1932: 397. Locality To Noi, Myanmar. Types, lost. ; 1972: 196 (?H morph syn. *youngi*); ?*Pheretima youngi* Gates, 1932: 406. Type locality Pang Wo, Myanmar. Types either lost or in Calcutta Museum: 3077.

Pheretima illota : Ohfuchi, 1956: 136 [non Gates, 1932: 397; - misidentification from Ishigaki and Iriomote Islands (Ibaruma, Hatoma-jima, Hoshitate)].

Amynthas '*illotus*': Easton, 1981: 53; Tsai *et al*., 2002; Blakemore, 2003.

Remarks: The diagnosis of *Amynthas illotus* (Gates, 1932) was restricted by Gates (1972: 196) to exclude the Japanese specimens identified by Ohfuchi (1956), but no alternative was provided, and Easton (1981) believed that a new name was not warranted for these parthenogenetically degraded morphs. Gates (1972: 196) also surmized that his

subsequent *Amynthas youngi* (Gates, 1932: 406) [from Pang Wo, Myanmar with types either lost (Gates, 1972: 224) or in Calcutta Museum: 3077 (Reynolds & Cook, 1976: 191)] may be one possible candidate for the H morph, although information was lacking for confirmation of this. Tsai *et al*. (2002) have the distribution of *A. illotus* as Yunnan (China) and Ishigaki Island, apparently overlooking the type locality and accepting Ohfuchi's records, even though the diagnosis of these latter specimens differed considerably from Gates' original.

5/. ***Amynthas sheni*** (Chen, 1935).

Pheretima sheni Chen, 1935: 38. [From Hong Kong; eight specimens three of them aclitellate and all lacking spermathecae. Type described in the Museum of Fan Institiute of Biology, Peiping but also claimed in US National Museum: 20181].

Amynthas sheni : Sims & Easton, 1972: 236.

Remarks: Possibly a degraded morph of either *A. corticis* or *A. robustus*.

?6/. ?***Metaphire varians*** (Chen, 1938) **Comb. nov.**.

Pheretima (*Pheretima*) *varians* Chen, 1938: 385. [From Hainan. Types?].

Amynthas variens (part - not type, sic lapsus pro *varians*) : Sims & Easton, 1972: 236.

Remarks: Athecal (not primary type) components are unlikely to be in the *A. illotus* species-group; other components had spermathecal pores in 5/6 or 5/6/7. Described as 15-130 mm by 1-4 mm with 78-148 segments. Setae 20-100, always present on first segment. GMs numerous papillae in pre- and post-setal rows on 15,16-18 and 6,7-8,9; or only two large ones presetally on 17 in line with male porophores; or totally absent. From Hainan, possibly a hodge-podge of degraded morphs for more that one species but unusual in all having setae on first segment, perhap providing a means to identify the various components. Male pores (when present) on penes that are presumably retractable into copulatory pouches (hence *Metaphire*).

7/. **'*Pheretima*' *oyuensis*** Ohfuchi, 1937.

Pheretima oyuensis Ohfuchi, 1937a: 24. [From Akita-ken. Types?].

Pheretima cyuensis (sic, laps. pro *oyuensis*): Sims & Easton, 1972: 225.

'*Pheretima*' *oyuensis* : Easton, 1981: 54.

Remarks: Sims & Easton (1972: 225) have this degraded morph of an unknown species as *incertae sedis*; it was originally described as lacking spermathecae, genital markings, male pores, and prostates. The original description was based on two specimens that measured 50 and 55 mm had simple caeca and may thus be similar to *A. minimus* or possibly implicated in a species group not dissimilar to that involving *A. assacceus*

(Chen, 1938).

[**End of *A. illotus* spp-group**].

Amynthas incongruus (Chen, 1933)

Pheretima incongrua Chen, 1933: 270. [From Lin-hai-hsien, Chekiang, China. Types in US National Museum 20175].

Pheretima incongrua : Gates, 1935: 452 (said to have examined a type); 1959b: 13.

Amynthas incongruus : Sims & Easton, 1972; Blakemore, 2005; Blakemore 2005; Blakemore *et al.* 2006.

Diagnosis: Colour brownish, 55+ mm long; ca 55+ segments (types), or up to 207 subsequent accounts. Prostomium open epilobous with median groove anteriorly. Setae 45-60. First dorsal pore 11/12. Clitellum red 14-16. Spermathecal pores 0.5 C apart in 5/6/7. Male pores superfical on 18 just larger than adjacent genital markings, along with the latter surrounded by concentric grooves. GM small, seven anteriorly just lateral to spermathecal pores, one mesialy on posterior margins of 5 and 6; four papillae in vicinity of male porophore: one just in front and one just behind on either side of a pore. Septa 8/9/10 aborted. Intestine from 15. Caeca simple. Typhlosole present. Dorsal blood vessel complete, hearts 10-13. Holandric. Prostates sometimes lacking (i.e., parthenogenetic). Spermathecae in 6 and 7 adiverticulate. GM glands in 18.

Distribution: China and Taipei, possibly introduced or an aberrant form of some other taxon degraded by parthenogenesis. *A. incongruus* was first recorded from Taiwan by Gates (1959) and reported from Taipei by Tsai (1964), as shown by Shih *et al*. (1999) and Tsai *et al.* (2000a); see also Blakemore (2005) and Blakemore *et al.* (2006). It may now be compared with *A. pallidus* (Michaelsen, 1892).

Remarks: Probably it should be recorded as a parthenogenetic "*sp. incertae sedis*" in the *A. morrisi* spp.-group. *A. lubricatus* (Chen, 1936) may be a synonym lacking markings.

Amynthas juliani (Perrier, 1875)

Fig. 2.8 *Amynthas juliani* diagramatic after Michaelsen (1910, fig. XX).

Perichaeta Juliani Perrier, 1875: 1045. [Type locality Saigon, Vietnam. Types (five of)

in Paris Museum, 584]; Beddard, 1890: 67.

Pheretima juliani: Michaelsen, 1900: 419 [*incertae sedis*, no description of internal organization]; Michaelsen, 1910: 102, fig. XX [redescription of Paris types].

Amynthas juliani et julianus (laps.): Sims & Easton, 1972: 235 (*diffringens*-group), 243.

(The following description from Michaelsen, 1910).

Remarks: Cf. Japanese *A. fuscatus* (Goto & Hatai, 1898) and synonymy from Blakemore (2003; 2005; 2007), and also cf. *Metaphire malayana/forbesi*.

Diagnosis: *Amynthas* with paired spermathecal pores ca. 0.3 circumference apart in 5/6/7/8/9. Male pores superficial on small porophores on 18. Genital markings large paired in line with male pores in 17, 19-20 or 22. Intestinal caeca simple from 27.

Distribution: Vietnam, and Laos (e.g. Thai & Samphon, 1989) and reported from near the river Pon, Sepon Laos (S. Spiridonov pers. comm. 21st December, 2004).

Habitat: ?

Behaviour: ?

Length: 450 mm.

Width: 4-7 mm.

Segments: 210.

Colour: dark brown, almost black.

Prostomium: ?

First dorsal pore: 12/13.

Setae: Numerous, 74-127 per segment.

Nephropores: Not reported.

Clitellum: Annular 14-16, ventral setae not visible.

Male pores: Widely paired superficial on 18 on large papillae with 14 setae between.

Female pores: Single on 14.

Spermathecal pores: Four pairs in 5/6/7/8/9 ca. 0.3 circumference apart.

Genital markings: Large paired in line with male pores in 17, 19-20 or 19-22.

Septa: 5/6-8/9 thick, 9/10 aborted, 10/11-13/14 thin.

Dorsal blood vessel: Single.

Hearts: Last pair in 13.

Gizzard: In 8.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): ?; caeca "zipfelförmige" (i.e., conical) in 27, but extending from 28-26,25; typhlosole not reported.

Nephridia: Meroic.

Male organs: Testes/funnels holandric, in 10 & 11 in sacs; seminal vesicles large in 11 & 12.

Ovaries: In 13(?).

Prostates: Racemose glands large, duct muscular, copulatory pouches absent.

Spermathecae: Four pairs, ampulla saccular with short duct, with short diverticulum.

Gut contents: ?

Remarks: The large size and locality within the '*Pheretima* domain' suggest that this species may be endemic in Vietnam; it is included here as it appears to have few other records (since listing as *incertae sedis* by Michaelsen, 1900); also it is similar to several other species in the southeast Asia region (cf. *Pheretima darnleiensis*). An unusual features is retention of septum 8/9 (as also found in *P. darnleiensis*).

Amynthas lavangguanus (Gates, 1957)

Fig. 2.9 *Amynthas lavangguanus*, Rennell specimen (a) ventral view, (b) prostate, (c) polythecal spermathecae *in situ*, (d) dorsal view of prostomium; (e) intestinal caeca in 26. (After Blakemore, 1997a).

Pheretima lavangguana Gates, 1957: 14. [Type locality Lavanggu township and Lake Te-Nggano, Rennell Island. Types Zoologisk Museum Copenhagen and British Museum, 1957:11:5:27/33 (Syntypes)]. [Sometimes misdated "1959"].

Pheretima solomonis (part): Lee, 1969: 346.

Amynthas lavangguanus: Sims & Easton, 1972: 213 (*bifidus* group); Blakemore, 1997b:18, fig. 1.

(This account taken from examination of syntypes, new material, and earlier reports).

Diagnosis: *Amynthas* with pores of polythecate spermathecae, numbering three or four per side, in 4/5/6/7/8/9. Genital markings paired in 17-20. Male pores superficial on 18 within crescentic marks. Intestinal caeca simple in 26.

Distribution: Rennell Island, Solomons and Hawaii (see Remarks below).

Habitat: ?

Behaviour: ?

Length: 75-100 mm.

Width: ca. 5 mm.

Segments: 86-94.

Colour: Yellow-brown with bluish mid-dorsal line, clitellum buff.

Prostomium: Open epilobous.

First dorsal pore: Between 9/10-12/13.

Setae: Numerous, ca. 52-66 per segment, not visible on clitellum; setae between male pores (ornamented?).

Nephropores: None.

Clitellum: Annular 14-½16.

Male pores: Superficial 0.3 circumference apart on 18 between laterally crescentic tumescences.

Female pores: Single or closely paired on 14.

Spermathecal pores: Five sets of polythecal batteries in furrows 4/5/6/7/8/9.

Genital markings: Presetal, discs paired in line with male pores in 17, 18 and 19, midventral pairs in 17-20 (i.e., appearing in ranks); small mid-ventral markins possible in 6/7 and 7/8.

Septa: 5/6/7/8 thickened, 8/9 aborted, 9/10 weak and thereafter only slightly thickened or membranous.

Dorsal blood vessel: Single

Hearts: 10-12.

Gizzard: Muscular and spherical in 8 (displaced to 9-10) with proventriculus in 7.

Calciferous glands: Absent but oesophagus dilated in 10-12,13.

Intestine origin (caeca, typhlosole): 14,15; paired caeca small in 25, typhlosole absent.

Nephridia: Meroic, tufted in 4-6 otherwise numerous; absent from spermathecal ducts.

Male organs: Testes/funnels iridescent in sacs in 10 and 11, seminal vesicles in 12.

Ovaries: Paired in 13; ovisacs small in 14.

Prostates: Large, racemose occupying 17-20, slender duct forms hairpin loop.

Spermathecae: Polythecal in batteries of three or four on each side in 5-9, ampullae conical on longer ducts each with a slender-stalked diverticulus (iridescent). Although the spermathecae were buried in nephridial forests on body wall, their ducts were clear of nephridia.

Gut contents: Red clay and organic debris.

Remarks: Sims & Easton (1972: 214) remarked that the polythecal *Amynthas lavangguanus* exemplified several difficulties posed by their principal co-ordinates analysis of characters and their generic redefinition of *Amynthas*. This species is similar to acaecal *Polypheretima sibogae* (Michaelsen, 1922) from Lombok, *Amynthas*

bifidus (Gates, 1937) from Solomons and *Amynthas blackwenni* (Ude, 1925) from Borneo, all of which are polythecal (cf. *A. forbesi* which may be incipiently polythecal). *Amynthas bifidus* itself closely resembles *A. brevicincta* (Gates, 1958: 3). Lee (1969: 346) reasoned that *lavangguanus* and *bifidus* were synonyms of *Amynthas solomonis* (Beddard, 1899) – that was placed in an *hexathecatus*-group by Sims & Easton (1972) – although Blakemore (1997: 22) again separated them. Gates (1958: 6) notes similarity of an '*orientalis* species complex' composed of *P. orientalis, albobrunnea, sodalis* and *pauaiensis* Beddard, 1912 from Luzon, Philippines that may prove to be a single species in which individual genital markings vary greatly that were perhaps close to the source of the Solomon species. He thought the Solomon species were neoendemics that differ, primarily, on these points: *solomonis* and *brevicincta* one pair of spermathecae in 5-9; *bifidus* two pairs of spermathecae in each of 5-9; *lavangguanus* more than two pairs in some or all of segments 5-9; *bleckwenni* polythecate in 6-9.

The unconfirmed Hawaii report is from the Bishop Museum website (http://www2.bishopmuseum.org/HBS/invert/oligochaeta.htm May, 2005).

Amynthas loveridgei (Gates, 1968)

Pheretima loveridgei Gates, 1968: 257. [Type locality Honey Lake, 5 Miles W of Greenville, Madison County, Florida, collected 27th May, 1966 by E.V. Komarek. Syntypes (many specimens, some dissected) in British Museum 1967:5:8:26 (Gates, Sims & Easton, 1972: 181 and pers. obs. RJB 19.VI.2013) stated as "1967:5:8:28" (sic) and Tall Timbers Research Station #142 (Reynolds & Cook, 1976: 130) – this later corrected and a transfer noted – see Material Examined below]; Gates, 1982: 57.

Amynthas loveridgei: Sims & Easton, 1972: 236 (*A. morrisi* group);Chang et al. 2014: fig. 12.

Material Examined: "*Pheretima loveridgei* Gates 1960 SYNTYPE"; "BMNH 1969.5.8/26 Loc. Greenville Madison Country (sic) Florida U.S.A 27th May 1966 Coll E.V. Komarck (sic) Ref. Gates 1968 J. nat. Hist. 2 p. 267"; "Cat. No. 142 Tall Timbers R.S. *Pheretima loveridgei* Fla. Madison Co. 5m W. Greenville 27 May 1966 E. V. Komarek, Sr TF 29" (there were two labels like this last). Sample jar contained many specimens, some dissected, in reasonable condition. Reynolds & Cook (1993: 25) record 1967:5:8:28 (laps.); TTRS 142 "*Syntypi translati ad USNM 136910*".

Smithsonian catalogue lists "*Syntype*" and records 30 specimens with Accession Number 382788 and USNM #136910 (http://collections.si.edu/search/).

Diagnosis: *Amynthas* with paired spermathecal pores ca. 1/2 body circumference apart in furrows 5/6/7. Length 90-110 mm. Segments 118-169. First dorsal pore 11/12. Male pores absent (or obscure). GMs as small discs in front of and behind spermathecal pores and as three sets of weak tubercles on each side of 18 in position of male pores and more medially. Prostates present or absent. Gates also reported loss of one or more spermathecae.

Distribution: USA (e.g. Florida, Georgia, Minnesota) and Rose Cottage, Sandy Bay, St Helena in South Atlantic. The original oriental homeland (and full synonymy?) for this transported species is unknown.

Habitats: Nursery beds, plantations and cottage garden. Also "*sod rotations*" of Bahiagrass/Peanut/Cotton Cropping Systems.

Behaviour: ?

Length: 55-113 mm.

Width: 3-6 mm.

Segments: Mean 150.9487! (n = 39).

Colour: Brownish.

Prostomium: Closed epilobous.

First dorsal pore: 11/12.

Setae: Numerous ca. 40-60 per segment.

Clitellum: Annular 14-16.

Male pores: "*not recognized*" but presumed "*superficial*" within crescentic grooves.

Female pores: Single, central on 14.

Spermathecal pores: Two pairs in 5/6 and 6/7 lateral, ca. 0.5 circumference apart.

Genital markings: In region of spermathecal pores, postsetal in 5, 6 in front of each pore, presetal pairs in 6-7 just behind intersegments and just median to pore levels (once a median tubercle present on 7); in region of male pores paired equatorial patches on 18 had three rather indistinct tubercles on each side, with the lateral-most one in contact with the other two which are just median and pre- and post-setal.

Septa: 5/6/7 muscular.

Dorsal blood vessel: ?

Hearts: 10-13.

Gizzard: As usual.

Calciferous glands: ?

Intestine origin (caeca, typhlosole): 15; caeca from 27 to 23. At the region of the caecal origin, a 1 mm lamelliform dorsal typhlosole commences.

Nephridia: Meroic.

Male organs: Testes/funnels holandric in membranous testis sacs in 10 and 11; seminal vesicles small in 11, (12?), pseudovesicles in 13-14. Sperm absent.

Ovaries: As usual.

Prostates: Racemose from 16,17-23,24; or glands may be absent with only ducts remaining.

Spermathecae: Small, paired in 6 and 7 with diverticula shorter than main axis of ampullae. Sometimes lacking or abnormal. Sperm absent.

Intestinal caeca: Simple with smooth margins (pers. obs. RJB 19.VI.2013).

Gut contents: Mostly earth, occasionally some leafy organic matter.

Reproduction: Parthenogenetic, resulting in "*morphologically definable clones or morphs*"; possibly with two breeding periods in the life-history according to Gates.

Notes: Gates noted much mucus in the body cavity. He separated this taxon from *A. morrisi* on the basis of its "*GM pattern, number of segments, etc*." Gates (1968: 260) comments that the parthenogentic method of reproduction, as in other pheretimas, permits more rapid accumulation of mutations than if reproduction had remained amphimictic. However the possibility remains that *A. loveridgei* is a synonym of some other taxon with spermathecal pores in 5/6/7 (or some similar combination!), e.g. the 25 taxa listed above under '**Remarks on possible synonyms of *Perichaeta barbadensis***'; and cf. Gates' own confused description of *Pheretima hawayana lineata* that is possibly retained on its distinctive male pores. *A. infuscuatus* Jiang & Sun, 2014 is similar except it lacks the markings around the spermathecal pores and it apparently retains spermathecal diverticula and prostates.

Amynthas mekongianus (Cognetti, 1922)

Fig. 2.10.1. *Amynthas mekongianus*.
Fig. 2.10.2. *A. mekongianus* known distribution in Mekong River region.

Megascolex (*Promegascolex*) *mekongianus* Cognetti de Martiis, 1922: 3 (figs. 4-8); Sims & Easton, 1972: 223 [et *mekongiana* (laps.): Sims & Easton, 1972: 244 "***Species incertae sedis***"]; Reynolds & Cook, 1976: 135. Type locality: Ban Leum on the

River Mekong; collected by Dr. Malcolm Smith. Holotype Natural History Museum, London BMNH: 1921:7:30:4. Poorly preserved, aclitellate subadult with "the internal organs of the anterior end rather messed about as a result of the previous dissection" (Gates, 1934), possibly also heavily infected with gregarines; labeled: "*Megascolex* (*Promegascolex*) *mekongianus*. 1921.7.30.4 (Type). R. Mekong (Ban Leum) Annam. Pres. Dr. Malcolm Smith." Specimen re-inspected by Gates (1934: 260) [and Sims & Easton (1972)?], not re-inspected here due to its stated poor condition.

Pheretima mekongiana : Gates, 1934: 260.

Pheretima fluvialis Gates, 1939: 89; Gates, 1972: 186, 215 (where he notes its similarity to *A. juliani*); Thai & Samphon, 1989: 62 Tabl. 2 (paper in Vietnamese). **Syn. nov.** (Blakemore in Blakemore *et al.*, 2007) [Type locality Chiengsen Kao, Thailand, in mud on bank of the Mekong River (ca. 20°15" N, 99°85" E). Types in U.S. National Museum, (#20564): described as three batches of 5 juveniles, one juvenile, and 3 partially clitellate plus 4 clitellate specimens (total 13) all collected from mud on bank of Mekhong (sic) River, Chiengsen Kao [also spelt "Chiang Saen", "Chieng Saen Kao", or "Chieng-sen-kao'], collected 15-16th January, 1937 by H. G. Deignan. [Ornithologist Herbert Girton Deignan (1906-1968) was an authority on the birds of Thailand (Deignan, 1945) who on the same trip also collected fish that are deposited in the Smithsonian Institution. Ecological information of the region can be found here: http://www.arcbc.org.ph/arcbcweb/wetlands/thailand/tha_chisaebas.htm (December, 2004)]. [Non *Pheretima fluvialoides* Huynh Thi Kim (H.T.K.) Hoi, 1998: 10, figs 1-5. From Dak Lak, Central Highlands of Vietnam].

Amynthas fluvialis : Sims & Easton, 1972: 235, 242 [*A. diffringens* (= *A. corticis*) species-group]; Reynolds & Cook, 1976: 102.

Amynthas mekongianus : Blakemore, 2007; Blakemore in Blakemore *et al.*, 2007 (**comb. nov.**, syn. nov. *fluvialis*).

Locality Note: The locality was given as "*Ban Leum on Mekong River, Annam*" by Cognetti and, because Annam = Central Vietnam, as "from Vietnam" by Sims & Easton (1972: 223). In the current revision the actual Mekong River type-locality is uncertain but, as argued in the Discussion below, is probably in Thailand or Laos, and not in Vietnam.

Taxonomic Note: The following description is based upon Cognetti's original (in italics

to which a segmental count of one must be added), on Gates' (1934) reinspection of the type, Gates' (1939) *Pheretima fluvialis*, the account in Sims & Easton (1972) and, especially, from recently collected material that is in better condition than the type.

Diagnosis: *Amynthas* with four pairs of spermathecal pores ca. 0.2 body circumference apart in furrows 5/6/7/8/9. Male pores paired superficial ca. 0.2 circumference apart on flat porophores on 18. Genital markings absent. Clitellum impinging on segment 17. Oesophageal gizzard weak in 8. Intestinal caeca simple originating in 27. Length to 2,900 mm. Septum 8/9 present and muscular. Spermathecal diverticula zig-zaged, each enveloped in a thick sheath.

Distribution and habitats: Mud or sand of banks of the Mekong River.

Current specimens inspected: Six matures and one sub-adult, all clitellate, from banks of the Mekong River, 16km upstream of Vientiane Laos; collected and preserved in formalin collected in two batches on 19th December 1998, and 5th March, 2001 by Mr. Koiwaya and Tomoko Uchida of YNU. Details of specimens are: the smallest 690 mm with 305 segments (dissected and sketched), the largest 1,920 mm with 477 segments (male field sketched), a mature length 1,780 mm with 508 segments (this specimen fully dissected and figured here, it has segments 243, 300 and 306 fused and merged with adjacent segments), another mature was 1,430 mm long with 361 segments.

Body: Elongate and cylindrical. Lengths; 1,000 mm (Cognetti); 365-555 mm (Gates, 1939); 690-1,920 mm (current preserved specimens), to 2,900 mm when collected from the field (Koiwaya, 1999). Widths: 4-8 mm (Cognetti); 6-8 mm (Gates); 5.5-10.0 mm (current).

Segments: 370 (Cognetti); not recorded (Gates); 361-508 or as many as 580 (current); much secondary annulation and setal rings most prominent in hind segments.

Colour: Gray, darker on the back (Cognetti); dark greyish or brownish grey (Gates, 1939); current specimens grey with darker brown clitellum, but alcohol in their jar has brownish tinge suggesting there is some colour leaching.

Behaviour: Limicolous (mud dwelling). No iridescence was noted in sperm funnels nor spermathecal diverticula of clitellate specimens (Gates, 1939 and current), thus the species possibly has seasonal reproduction (with breeding season including January-March) or it may be incipiently parthenogenetic.

Cocoons: Information not available.

Prostomium: Poorly distinguished (Cognetti), perhaps because anterior segments were damaged or deleted in his specimen; not noted by Gates; small pro-epilobous (current).

First dorsal pore: *10/11* (Cognetti); 12/13 (Gates and current).

Setae: "*Setal ring of each segment protrudes in a special way especially in the mid and hind body; in the anterior they are slightly larger; they are in a continuous circle except in the 2nd segment where only 46 setae are recognized with a wide ventral interruption (fig. 4). In the segments that follow, until the 25th, they number approximately 100 (e.g. 93 on the 17th segment). In shape the setae are nearly rectilinear, the nodule is moved towards the apex (fig. 5); length approximately 400μ, thickness 20μ*" (Cognetti); mostly 99-118 per segment (Gates, 1939); numerous, ca. 100 small black setae in continuous ring in each segment except peristomium and periproct (current).

Nephropores: Not found.

Clitellum: Not developed (Cognetti); annular in 14-16 and just into 17 with dorsal pores obscured (Gates, 1939); from 14 almost to setal arc of 17, some ventral setae visible (current).

Male pores: "*Male pores on 17th segment, on tubercules (penises) extending more laterally than medially. Between the two intumescences are 10 setae (fig. 6). The interval between the male pores is equivalent to approximately 1/6 of the perimeter*" (Cognetti); or as "short transverse slits on 17 each male pore towards lateral margin of a fairly large disc that is apparently retractile into the parietes. Just lateral to each male-pore disc there is a rather crescentric but deeply bowed groove, the concave side of the groove facing midventrally" (Gates, 1934). Similar in current specimens but superficial on 18 about 0.2 circumference apart with 10 or so setae between pores. Some variation in male pores allows either circular or hour-glass shaped low, flat porophores with actual male pores at centres; sometimes with a lateral bowed lines (seen on both sides in one specimens or on either rhs or lhs in two other specimens). Similarly, Gates (1939: 93) describes the pores as "tiny transverse slits on centres of disc-shaped porophores (that can be slightly retracted and covered by lid-like lateral flaps?)."

Female pores: Not mentioned by Cognetti; single on 13 (Gates, 1934); not mentioned by Gates (1939); but as usual on 14 in current specimens.

Spermathecal pores: *Four pairs in 4/5/6/7/8 in line with male pores* (Cognetti and Gates, 1934); in 5/6/7/8/98 ca. 0.2 circumference apart (Gates, 1939 and current).

Genital markings: None (all descriptions).

Septa: *3/4 to 7/8 greatly thickened and funnel-shaped, 8/9 absent, 9/10 and following thin* (Cognetti); 4/5-8/9 thickened and extending posteriorly, 9/10 aborted, 10/11 thin,

11/12 is thin with web-like fibres on either side, following septa are all thin (Gates, 1939 and current).

Dorsal blood vessel: Single (Gates, 1939 and current).

Vascularization and hearts: Not mentioned by Cognetti; in current specimens hearts are in 10lhs only, and large, paired in 11-13 with complex capillary systems, plus in 5,6-8 are blood-glands with lateral vessels. Although these large blood glands have many tubercules, it is not possible to say whether they are parasitic gregarine cysts as per Cognetti who has them in 4-7, or acinous masses (i.e., with several small sacs) as per Gates (1939) who has them in 4-9 and gives much detail on other blood vessels: e.g. he notes that the heart in 9 is single and may be on either the left or right side and in 10 the hearts are replaced by looping vessels and that the last pair of hearts is in 13.

Gizzard: "*muscular in the 7th segment, moderately sturdy, but with covering of inner cuticles*" (Cognetti); weakly muscular to vestigial in 8 between septa 7/8 and 8/9 that extend backwards (Gates, 1939 and current).

Calciferous glands: Oesophagus pouches absent.

Intestine origin (caeca, typhlosole): "*In 14 with simple paired, digitiform caeca in 26-21*" (Cognetti); in 15 with elongate paired caeca in 27-23 simple but with slightly incised posterior edge in older specimens; a dark (vascularized) deeply lamellar typhlosole develops from 25,26 (Gates, 1939 and current) plus Gates says the typhlosole ends about segment 150.

Nephridia: "*Diffuse*" (Cognetti); meroic, tubules numerous especially obvious on anterior septa and blood vessels, e.g. in segment 5; absent from spermathecal ducts (current).

Testis/sperm funnels: Testis not mentioned but "*A pair of seminal vesicles in the 10th and partly in the 11th segments; a second pair in 11 and partly in 12, each pair independent*" (Cognetti); in current specimens testis and funnels in combined sacs paired in both 10 and 11, with seminal vesicles in 11 and, a larger pair in 12. Gates (1939) describes a similar holandric arrangement in his specimens. Vasa deferentia (sperm ducts) can be traced back to the junctions of the prostatic ducts and glands.

Ovaries: Not discovered by Cognetti nor reported by Gates; small and difficult to see in current specimens paired in 13 with funnels passing to 14, as would be expected.

Prostates: "c*ontained in the 17th segment with one glandular portion (racemose) and a muscular duct folded to exit and joined by the vasa deferentia*" (Cognetti); ditto but in segment 18 in current specimens with U-shaped duct as also described by Gates

(1939). Copulatory pouches absent.

Spermathecae: "*distributed in segments 5 (two pairs), 6, and 7; their volume decreases gradually from the first to ultimate pair. Each spermatheca with a sacciform proximal portion wide and communicating via a short channel to the external pore where it meets the duct of a clavate diverticulum*" (Cognetti); in current specimens in 6 (2 pairs), and paired in 7-9, diverticula flattened with irregular outline. Gates (1939) describes the diverticula as shortly zigzag looped, surrounded by a layer of tissue, which conceals the looping. It was not possible to tease out the diverticula in current specimens although the looping was visible through the membranous sacs. Spermathecal ducts free of nephridia.

Gut contents: Fine silty soil in current specimens; Gates (1939) describes gut as filled with sand in one of his specimens.

Ecology: Description and photographs of specimens collected from Mekong by Mr Satoshi Koiwaya (published in No. 9 Earthworm Newsletter, 1999 report; Japan January, 1999 edited by Dr S. Matsumoto in Japanese), in summary, says: "*During research in Laos, stories of an earthworm greater than 1m length in the banks of the River Mekong were told by the father of a friend from Vientiane. On 19th December 1998 there was the chance to collect worms. They produce copious surface casts and the worms were collected from the mud but were easier to obtain from below the water at depth of 40cms. The worms easily exceeded 2m when extended or held between 3 people. The maximum recorded was 2.9m. Preserved specimens were donated to Dr Tomoko Uchida at Yokohama National University for study*." These were the specimens newly described here by the senior author.

Remarks: It now seems obvious that a count of one needs to be added to Cognetti's description and, when this is done, *mekongianus* is seen to belong to the genus *Amynthas* where in normal specimens female pores and male pores are reasonably expected to be in 14 and 18, respectively, the gizzard behind 7/8, and intestinal caeca near 27. After inspection of the poorly preserved, damaged (and immature) type, Gates (1934: 260) thought that Cognetti's description was of an abnormal specimen of a "*Pheretima*". However, Sims & Easton (1972: 223) conjectured that Cognetti miscounted the segments externally where segments "*2 and 3 having either fused or one of them suppressed*", yet for some reason they postulated the gizzard is "*clearly in segment 5*" so they provisionally retained it as *species incertae sedis* in Cognetti's subgenus *Promegascolex* of genus *Megascolex*.

From inspection of new material here, it now seems most likely that Cognetti's specimen was abnormal or mutilated and thus placement of his species, as with *A. fluvialis*, in the prior genus *Amynthas* as defined by Sims & Easton (1972) is warranted. From this new material and the descriptions in Cognetti's original and in both Gates' accounts, the male pores are classed as 'superfical' thereby qualifying for inclusion in *Amynthas*, albeit Gates (1934) said for *mekongianus* that the type has "a fairly large disc that is *apparently* rectractile" and for his *fluvialis* he notes "*Presumably* the porophore can be slightly depressed" [Italics added]. In the current specimens some variability is permissible in the arrangement of the male pores that are, nevertheless, clearly superficial (cf. *Metaphire fluvialoides*).

Gates' (1939) *P. fluvialis* differs inconsequentially from the corrected account of Cognetti's species so is placed in synonymy while also offering slight augmentation of the original description due to the more usual nature of his material compared to Cognetti's. Gates (1939) though his *fluvialis* similar to *Amynthas juliani* (Perrier, 1875) from Ho Chi Minh City (Saigon), Vietnam that, however, has large genital markings in line with male pores in 17, 19-20 or 22. Despite his earlier redescription, the possibility that his new species was similar to *mekongianus* appears to have escaped Gates' attention. *Metaphire fluvialoides* (Hoi, 1998) (fig. 5) from Dak Lak province in the Central Highlands of Vietnam is maintained separately (see Blakemore *et al.*, 2007).

Amynthas minimus (Horst, 1893)

Fig. 2.10 *Amynthas minimus*, Samford specimens (a) larger, thecate morph, (b) prostate,

(c) spermatheca, (d) spermatheca of another specimen; (e) athecal morph, (f) prostate.

Fig. 2.11 *Amynthas minimus* specimen, ventral view with 18rhs prostate and dissection to show caeca.

Perichaeta minima Horst, 1893: 66, fig. 27. [Type locality Tjibodas, Java. Primary type in Leiden Museum: 1836].

Perichaeta pusilla Ude, 1893: 63 [non *Perichaeta pusilla* Ohfuchi, 1956 (= *A. assacceus*)].

Pheretima enchytraeoides Michaelsen, 1916: 33. [Type locality in Queensland].

Pheretima zoysiae Chen, 1933: 288, fig. 27. [Type locality Chekiang. Types in Nanking (Ann. 570) or in Smithsonian Institution].

[*Pheretima ishikawai* Ohfuchi, 1941: 248. From a cave 龍河洞は in Ishikawa-ken, Japan now an independent species restored by Blakemore 2018. Types?].

Pheretima humilis Gates, 1942: 120. [Type locality, "*Earth in large flower pots on west veranda of faculty house*", Judson College, Rangoon, Myanmar. "*The type locality and types destroyed during World War II*"].

Pheretima subtilis Gates, 1943: 104. **Syn. nov.?** [From manured ground in low damp Shan garden, Meung Nawng village, Salween ferry, Pany Long State, Myanmar near the Chinese border (Gates, 1961). Single softened and eroded specimen lost in WWII]. The only difference from the wide tolearance of *A. minimus* is male pores said to be in a "*slight parietal invagination*" but the specimen was mascerated, plus (unlikely) longitudinal genital markings in 22/23 and 23/24.

Pheretima minima: Gates, 1961: 298, 306, 308 (syn. *pusilla*, *enchytraeoides,* ?*zoysiae, ishikawai*); Gates, 1972: 201 (syn. *humilis*, ?*zoysiae*, ?*fungina*, ?*muta*, *ishikawai*); 1982: 57 (syn. *ishikawai*).

Amynthas minimus : Easton, 1979:119 (syn. *pusilla*, *enchytraeoides*); Easton, 1981: 55 (syn. *zoysiae*, *ishikawai*); Easton, 1982: 728 (syn. *enchytraeoides*, *pusilla*); Easton, 1984: 118.

Taxonomic Note: Easton (1979: 119) stated that *minimus* Horst, 1893 has priority over *pusilla* Ude, 1893.

Diagnosis: *Amynthas* with paired spermathecal pores c. 1/2 body circumference apart in furrow 5/6, occasionally absent. Small size, genital markings occasionally present small on pre- and postclitellar segments. Intestinal caeca simple.

Distribution: In addition to the oriental '*Pheretima* domain': USA, Hawaii, Cote

d'Ivoire, South Africa, Swaziland, Madagascar, Samoa; Papua New Guinea; and, in Australia, from Cairns (Michaelsen, 1916), Brisbane region and Springbrook, all in Qld. Removing *A. ishikawai* from synonymy may remove Japan as a location for this species because I can find no corroborative reports.

Locality: Samford; Taringa, Brisbane, Qld.; Rarotonga, Cook Island; Nagasaki, Japan collected 12th Sept., 2018 from vonSiebold's garden by R.J.B in KPMNH (new records).

Habitat: Under pasture, riverbank under litter; suburban gardens.

Behaviour: Rather docile, contracts on touch, only slight lashing response.

Length: 16-60 mm.

Width: 1.5-2.5 mm.

Segments: 74-100.

Colour: Pigmentless, anterior darker or pink, clitellum buff; gut contents visible through body wall as dark spiral.

Prostomium: Closed to wide open epilobous.

First dorsal pore: (11/12) 12/13 or 13/14 (only faintly visible on clitellum).

Setae: Numerous, ca. 40 per segment, not visible on clitellum; setae between male pores sometimes obscure.

Nephropores: None.

Clitellum: Annular 14-16.

Male pores: Wide apart on raised (may be flattened) circular porophores on, and filling width of 18 (sometimes appearing dumbbell shaped) about ten setae intervene.

Female pores: Single (closely paired?), central within small circular depression on 14.

Spermathecal pores: One pair in 5/6 widely separated, or absent.

Genital markings: Absent; or paired on 17 and 19 in line with the male pores and single, median on 20 (Michaelsen for Ude's *pusilla*); or small, presetal and paired on (some of) 5-8 and single central on 17 and 19-21 (Gates, 1961; 1972).

Septa: 5/6/7/8 thick, 8/9/10 aborted (or 8/9 weak), 10/11-13/14 medium.

Dorsal blood vessel: Single, continuous (always?) onto iridescent pharyngeal mass in 5. Ventral vessel bifurcates and describes gizzard.

Hearts: 9-13.

Gizzard: Muscular and spherical in 8 (displaced to 9-10) with proventriculus in 7.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): 14 or 15; simple, laterally paired caeca 26-24. Typhlosole present.

Nephridia: Meroic , forests of nephridia on anterior faces of septa 5/6-7/8 and on body wall equatorially in 8 and 9, less numerous in 10-12.

Male organs: Testes/funnels iridescent in sacs in 10 and 11, seminal vesicles in 11 and 12.

Ovaries: Paired 13 as rosettes with many eggs-sheets, funnels pass into 14.

Prostates: Large, racemose occupying 16-22, muscular duct forms hairpin loop; gland sometimes aborted (Gates, 1972: 202).

Spermathecae: When present: large elongate ampulla with equally long duct from which thin (regularly zigzag-looping) diverticular duct branches, reaching to near middle of ampulla with an elongate bulb (not iridescent).

Gut contents: Fine sand and organic debris.

Notes: There seems to be little of substance to separate Gates' *P. subtilis* from *A. minimus*, but the same could be said for several of the nominal species with spernathecal pores in 5/6 [cf. *Pheretima urceolata*] described and keyed out by Gates (1961: 304-312), indeed several were subsequently added as junior synonyms. Gates (1972: 202) presumed that parthenogenesis occurs in various morphs referred to this taxon as an H morph was at that time unconfirmed. However, Chen's (1933) species described from the lower Yangtse region appears to be of a sexually reproducing population, even though it may be exotic to the area as it was found only in the superficial roots of grasses, especially *Zoysia pungens* Willd var. *japonica* Hack. Another of Chen's bithecal species from south China, *Amynthas wui* (Chen, 1935: 109, fig. 1), is also closely similar apart from slightly more developed genital markings on 17.

In studies by the author, this species was beside the South Pine River, Samford in association with *Aporrectodea rosea* etc.and under pasture in low to very high numbers up to 500 m^{-2} in combination with *Drawida barwelli*. Both latter taxa were tested in the glasshouse and later introduced into field plots, as described by Blakemore (1994b). There appeared to be two superficially distinct forms which differ in size and behaviour: the smaller morphs contracting and becoming rigid on touch, whereas the larger darker coloured morphs respond with activity. The above description encompassed both types which were at different stages of growth (although both were clitellate).

***Amynthas morrisi* species-group** of Sims & Easton (1972)

[Cf. ***A. browni*** and ***A. loveridgei***].

Amynthas morrisi *s. stricto* species-complex

Tentative included taxa having mid-ventral genital markings:

A. morrisi (Beddard, 1892.)

A. pallidus (Michaelsen, 1892).

A. insulae (Beddard, 1896).

A. incongruus (Chen, 1933) (Taiwan specimens have midline GMs on 18).

A. lubricatus (Chen, 1936) may be a synonym, lacking markings

Pheretima monoserialis Chen, 1938 (has about 20 glands for each midline GM in 16-20).

?*Pheretima tripuncta* Chen, 1946 (GMs mid-ventral in 6-8 and paired near male pores; spermathecal pores close to intersegments 5/6/7 but anteriorly in 6 & 7, i.e. strictly complying with Sims & Easton's *canaliculatus*-group – see Fig.).

Several more recent Oriental taxa may also be implicated but DNA data are required for resolution, ideally based on topotypes or neotypes (as per Blakemore *et al*. 2010).

Key to historical members of *A. morrisi*-complex with spermathecal pores 5/6/7

1. Genital papillae mid-ventral in (6),7-8,(18) but not near male pores ..... *A. morrisi*
   Genital markings (absent?) or with different arrangement 2
2. Spermathecal diverticulum longer, swollen (intestinal caecum form?) .... *A. pallidus*
   Spermathecal diverticulum shorter, thin; intestinal caecum incised .... *A. insulae*

Amynthas morrisi (Beddard, 1892)

Fig. 2.12b Beddard's original figure from Beddard (1892, Pl. IX, figs. 1), annotated with Rosa's (1896: figs. 2-3 of possibly the same taxon).

Fig. 2.12c Sophie M. Fedarb (1898) fig. 1 of *Perichaeta cupulifera* synonym.

Fig. 2.12d Composite figures – not the restricted *A. morrisi* – with modified sketches from Sims & Easton (1972: figs. 1A of 18rhs male pore, 1H of caecum that they call "complex") that is likely for *A. insulae* or similar; and Easton (1982: fig. 4d) that both fail to show the typical, single, mid-ventral markings also cf. Sims & Gerard (1985, 1999: fig. 47a).

Perichaeta morrisi Beddard, 1892a (July): 166, Pl. IX, fig. 1. [From Kew Gardens from Penang type-locality (under ICZN, 1999: Art. 76.1.1). Types in British

Museum 1904:10:5:199-201 "*three or four specimens, of which only one was sexually mature*", and labeled as from Hong Kong according to Gates (1972: 203) but this contradicted by the current study – see Materials Examined. Types in British Museum 1904: 10:5:199-201 inspected by RJB 19.VI.2013 and (missing) specimen 199 newly selected as lectotype]; ?non Beddard, 1900a: 420, 423 (describing Hong Kong non-type specimens as part of *Amyntas hawayanus* ; two of these were redescribed by Gates, 1937: 361).

[?*Perichaeta barbadensis* (?part "a" and/or "c") Beddard, 1892a (July): 167, Pl. IX fig. 7 of "c", (specimen "a" not figured despite text claim, cf. "b" which is *A. gracilis* as fig. 6 clearly shows instead). From Kew in material from Barbados type-locality (see ICZN, 1999: Art. 76.1.1). Types in British Museum 1904:10:5:11-13 inspected by RJB 19.VI.2013 and (missing) specimen 12 newly selected as lectotype which likely agrees with prior *A. gracilis*. Described with spermathecae either in 6&7 in "a" and "c" or in 6-8 in "b"]; Beddard, 1900a: 425 (stating one type spermathecae were actually in 7&8 not 6&7, but did not tell if it is "a" or "c"), this now irrelevant].

[?*Perichaeta mauritiana* Beddard, 1892a: 170, Pl. X figs. 5-6. From Kew in material from Mauritius. Types in British Museum listed as BMNH 1904:10:5:203-205 suggesting three specimens, but the original misplaced by Beddard (1900a: 425) who described other supposedly similar specimens. Possibly a morph of *gracilis* since spermathecae are in 7&8 and markings only near male pores – three per side but shown as more horizontal rather than oblique as usual in *A. gracilis*]; Beddard, 1900a: 425 (describing two other supposed non-type specimens with spermathecae in 6-8,9 one that was more similar to *gracilis*)].

Perichaeta morrisi : Beddard, 1895a: 394, 400, 411; Rosa, 1896: 516, figs. 2-3 (of proatate and spermatheca) [specimens from Padang, Sumatra reasonably expanded the definition to include mid-ventral markings in 6 and 18, and first dorsal pore in 10/11].

[*Amynthas barbadensis* : Michaelsen, 1900: 254 (syn. *pallida* Michaelsen, 1892: 227, *amazonica* Rosa, 1894: 14, *sanctijacobi* Beddard, 1895: 61, *cupulifera* Fedarb, 1898: 445 – I think this is in error as only *barbadensis* specimen "c" complies)].

Pheretima morrisi (part.?): Michaelsen, 1900: 287; Ude: 1905: 434; Chen, 1931: 148; 1933: 267 [syn. *insulae*, *hawayana lineata*, *browni*: sensu Gates, 1932 (not 1931)]; Gates, 1937: 361 (inspecting BMNH alledged Hong Kong types); 1939:

453 (syn. *insulae, browni* part.); 1968: 253; 1972: 202 [syn. *browni* (part.) Stephenson, 1912: 274 - this synonymy by Gates is obviously a mistake as *Pheretima browni* Stephenson, 1912: 273 has spermathecal pores in 7/8/9 amongst other differences, cf. *Metaphire californica*; *hawayana lineata*]; Gates, 1982: 59 (no synonyms listed just broad definition).

Amynthas morrisi (part.?): Sims & Easton, 1972: 236, figs. 1A (of 18rhs male pore of non-type), 1H (of incised caecum they call "complex" of non-type); Easton, 1981: 55 (syn. *exiloides*: Ohfuchi, *elongata*: Ohfuchi); Easton, 1982: 729, fig. 4c; Sims & Gerard, 1985: 132, fig. 47a (syn. *barbadensis*, *mauritiana*); Blakemore, 2002, Blakemore, 2003[syns. *barbadensis*, *?pallida*, *hawayana lineata*, *exiloides*: Ohfuchi, 1956 (non Chen, 1936), *elongata*: Ohfuchi, 1956 (non Perrier, 1872)]; Shen & Yeo 2005: 24 [syns. *barbadensis* (part.), *pallida* (part.), *amazonica, insulae, cupulifera, hawayana lineata*]; Blakemore *et al*., 2006: 228 [syns.? *barbadensis* (parts ?"a" and "c"), *mauritiana* (most likely a variety of *gracilis*), ?*pallida*, ?*amazonica* , ?*sanctijacobi*, ?*cupulifera*]; Blakemore 2008; 2010; 2012; Chang *et al.*, 2009: 60, fig. 26 [photos with 26A of 18rhs male pore and GMs corresponding almost exactly with the supposed type 1904:10:5:199 (pers. obs.), therefore a likely misidentification and probably close to *A. cupuliferus* itself a probable synonym of *A. pallidus* as Michaelsen thought]; Natural History Museum, 2014 (curatorial website http://www.nhm.ac.uk/research-curation/scientific-resources/biodiversity/uk-biodiversity/uk-species/species/amynthas_morrisi.html) (syns. *mauritiana, barbadensis* both these herein revised).

Etymology: Named for Sir Daniel Morris, Assistant Director at Kew Gardens from 1886-1898 before he became Imperial Commissioner of the West Indian Agriculture Departent (where organic pioneer Sir Albert Howard also worked from 1899-1902).

Material examined: Natural History Museum, London 1904:10:5:199-201 labelled: "*Perichaeta morrisi* Beddard, 1892 TYPE 1904:10:5:199-201 Loc: Penang Island, west of Malakka, Sumatra (Padang). Ref. Proc. Zool. Soc. L. 9(1): 166"; "*Perichaeta* Penang"; plus a label from Beddard that is illegible. [NOTES: The location note "*Sumatra, Padang*" is seemingly a mistake as (although it where Rosa, 1896 recorded *morrisi* from) it is 700km from Malaysian Penang (5º24'N 100º14'E) and far from Malacca; actually this location is copied from Michaelsen, (1900: 287) who gives location: "*Insel Pinang westlich von Malakka, Sumatra (Padang)*". Reynolds & Cook

(1976: 149) mistakenly give this same registration number for *P. padasensis* (Beddard & Fedarb, 1895)]. Sample contains four specimens, none dissected, one is mature and three are aclitellate. The mature specimen is figured here but cannot possibly be the type of *A. morrisi* as it is undissected and differs considerably; the other three sub-adults may be syntypes but were not used originally since Beddard (1892: 166) says – "*Three or four specimens were forwarded to me, of which only one was sexually mature; the following description is based upon that specimen.*"

The lectotype is hereby designated as 1904:10:5:199 under ICZN (1999: Art. 74 with amendment) it being the sole name-bearing individual on which the original *A. morrisi* description by Beddard was based having a (contracted) length of 52 mm with 93 segments and illustrated at natural size in his fig. 1 (as 80 mm) and even though this specimen is now misplaced, the objective being to define this taxon in the interest of nomenclatural stability. The three aclitellate syntypes (1904:10:5:200-201) become paralectotypes only because Beddard mentioned them as "*three or four specimens*", they formed no part of the description and neither did the mature specien that was presumably added to the jar subsequently (as here figured and traced to same batch as Hong Kong specimens 1904:10:5:106-116, in particular one as described by Beddard, 1900a: 424).

At the same time, I choose specimen 1904:10:5:12 as lectotype for Beddard's (1892) *P. bahamensis*, this being the one he described as specimen "b" and figured (fig. 6 but mistakenly said it to be specimen "a"). This specimen cannot now be traced in the Museum collection (pers. obs.) but it is reasonably accepted to be the same as *Amynthas gracilis* (Kinberg, 1867) and thus fixing the type to this specimen allows the name *bahamensis* to definitively enter synonymy of *gracilis*. The other two specimens, 1904:10:5:11 and 1904:10:5:13 – which are of two different taxa – now loose any nomenclatural status with the restricted definition of *bahamensis* aiming to enhance the stability of nomenclature which has been highly confused for 120 years or so since Beddard (1872).

Distribution: Described from Kew but originating from Penang the following records all now require verification. Possibly native to southern China/Japan where it was at least misidentified as *Pheretima elongata* by (Ohfuchi, 1956), *A. morrisi* is supposedly peregrine in: Myanmar, Thailand, Vietnam, Taiwan, Malaysia inc. Penang, Singapore, and Sumatra; and outside the *Pheretima* domain in: Hawaii, USA, Mexico, South America, St Helena (recorded once – Gates, 1937: 318; Gates, 1969: 2), Ascension Island Gates, (1969: 2); and Caribbean [e.g. Equador, Chile, Argentina, Brazil, Guayana,

Mexico, Barbados and Peru from Brown & Fragoso (2007) also Guatemala (Gates, 1982)], Diego Garcia (Sims, 1971), Spain, Italy, Pakistan, India (Gates, 1972: 204), South Africa, PNG, and Australia. From South Africa, Zicsi & Reinecke (1992) recorded it from a riverbank in Potchefstroom and near Sabie, it is also reported from Pretoria. Sillitoe (2003) reports "*Amynthus morrisi* (Group)" from New Guinea. Only one previous report in Australia – from the grounds of the old Queensland Museum, Brisbane (Easton, 1982). How many of these are *A. morris* s. strict. are unknown as this may now only refer to the *A. morrisi* spp-group distribution, and that in part only with the current restriction of the name and the resurrection of synonyms.

Diagnosis: The type-description is short: Length stated as 52mm (natural size of 80mm shown in his fig. 1 as noted by Rosa), segments 93. Spermathecal pores 5/6/7, male pores 18 not separated by a very wide interval (with minute papillae assumed nearby since there are glands internally). "*There are no papillae in the neighbourhood of the male pores*.." but "*..in the neighbourhood of the spermathecal apertures*" are central discs, mid-ventral, presetal in 7 & 8 plus Rosa found them mid-ventral in 6 in one and in 18 in two of his non-type specimens. Gizzard in septal space of 8-10; oesophagus in 10-14 dilated; intestinal caeca the usual pair. Spermathecae with diverticulum un-dilated about as long as the ampulla. Copulatory pouches absent (i.e., male pores simple). (Beddard thought the setae on clitellum were characteristic but these are likely due to maturity and interval after shedding and thus are irrelevant).

Notes: It is now necessary to restrict the definition of *A. morrisi* to those specimens that agree with the original in having paired mid-ventral markings on 7 & 8 and none around male pores.

The listed NHM type is undissected and does not correspond to the original description by Beddard thus the samples have been mixed at some stage between 1892 and 1904 when they were lodged, or afterwards.

Gates (1937: 361) claimed to inspect British Museum material he cited as: " *3 specimens labeled, 'Pheretima barbadensis 1904:10:5:11-12. Barbados. coll. Beddard' and 1 aclitellate and 1 partially clitellate specimen labelled 'Pheretima morrisi. 1904:10:5:106-116. Hongkong. coll. Beddard'* ". These are obviously not types of *A. morrisi*, but Gates goes on to say "*The British Museum specimens from Hongkong are, according to Dr. C.C.A. Monro, the types of P. morrisi*." The single clitellate syntype of Beddard's Penang species – now missing – was described with markings only mid-ventral in 7 & 8. Gates (1937: 362) described two Hong Kong pseudo-types, one

partially clitellate with markings mid-ventral in 6, 7 & 8 and also with paired lateral presetals each on 7, 18 & 19 along with two markings just median to each male porophore. This complies ***exactly*** with what Beddard (1900a: 424) said "*it was very general to find*" in several of his Hong Kong non-type specimens of "*morrisi*" with one individual in particular having median markings on each of segments 6-8. Another one Beddard (1900: 424) said "*was anomalous by reason of the fact that the 7th segment had no less than six papillae arranged in an irregular line along the middle of that segment*" – which is ***exactly*** what the mixed-type specimen (in jar 1904:10:5:199-201) now has – but this was not recorded by Gates. Gates (1937: 362) described the second aclitellate Hong Kong specimen with three marking on 7 and four on 18 but this does not comply with any of those given particulars by Beddard (1900: 424) and can be ignored too. The registration numbers (BMNH 1904: 10:5:106-116) suggest there were originally eleven specimens in the sample, and Beddard (1900: 424-245) provides details of ten or eleven of these Hong Kong specimens, thus it is unclear why Gates (1937: 361) could only record two specimens. Nevertheless, it seems Gates is mistaken in his assumption about these being *A. morrisi* types. It is now important to try to trace the eight remainder of the eleven Hong Kong specimens as these may contain the actual missing type accidentally swapped with the one Hong Kong non-type material presently in jar BMNH 1904:10.5.199-201 [these numbers themselves indicating three specimens but actually comprised of four, with one being the Hong Kong non-type specimen, as noted above and in designation of a lectotype below].

Also often confused and contradictory in his work, Gates (1939: 446), for example, claimed to inspect BMNH non-types from Hong Kong labelled "*P. barbadensis* 1904.10.5.1219.1228" containing three specimens of "*Pheretima barabadensis* and varieties?" and "*P. morrisi* 1904-10.5.453" that he said had four divers specimens; but a few pages later (Gates, 1939: 453) said these two jars contained, respectively, 31 (!) specimens and just three specimens of "*Pheretima morrisi*". This whilst he placed the type of *A. insulae* Beddard, 1896 and, even more unlikely, *A. browni* Stephenson, 1912 in synonymy of his confused concept of *A. morrisi*. Gates rarely provided figures for clarification.

Sims & Easton's (1972: fig. 1A H) was supposedly *A. morrisi* but the specimen concerned was not identfied. Interestingly, Sims & Gerard (1985, 1999: 132, fig. 47a, after Easton, 1982: fig. 4d) later said: "Amynthas morrisi *(Beddard, 1892a: 166) originally recorded as* Perichaeta barbadensis *Beddard, 1892a: 167 and* P. mauritiana

Beddard, 1892a: 170" and their figure of "*A. morrisi*" had genital markings below and just median to line of spermathecal pores in 6,7 and 8 and paired midventral in 18 and 19 and just above male pores and in a similar position on 19 (i.e., 14 total, all presetal but no single central as in the original!). These authors did not inspect types of any of these three taxa and their mistaken characterizations are now highly suspect.

There is no evidence to support *P. mauritiana* being the same as *P. morrisi* and thus Sims & Easton's (1972: 236, figs. 1A, 1H) plus Easton's (1982: fig. 4c) and Sims & Gerard's (1985, 1990: fig. 47a) are not representative of the type and are themselves probably composites. Ironically, Sims & Easton (1972) did not list type of *A. morrisi* in their study, and the specimen they figured is unknown, possibly a composite or one of the synonyms? Maybe it is from the *A. insulae* type (1904:10:5:86) as briefly redescribed below? Unfortunately, since the single type of *P. morrisi* cannot be located in the Museum collection, the definition of this species presently remains unverified.

Beddard's (1892: 170, fig. 6) *Pe. mauritiana* was yet thought by Michaelsen (1900: 316) and Gates (1972: 217) to belong to *hawayana* (= *gracilis*), or *barbadensis*, or *robustus*. Because of its markings around the male pores, *mauritiana* is a possible morph of *A. gracilis* lacking the anterior pair of spermathecae but this too needs confirmation. Cf. Sims & Gerard (1985; 1999) who oddly include it in synonymy of *A. morrisi* even though its spermathecae are in 7 & 8 **not** 6 & 7 as in *morrisi*. Pending inspection of its type, it is perhaps judicious to retain it too as a *species incertae sedis*.

Pe. mauritiana was described on a single specimen with GMs on 18 only, three per side, below and median to the male pores, thus unlike those of *A. morrisi* but possibly the same as *A. gracilis*. If they are the same as *A. gracilis*, but lacking the first set of spermathecae having the pores in 6/7/8, this begs the question why Beddard did not recognize it as similar to his *Pe. barbadensis* specimen "b" although, as in typical *A. gracilis*, this has pores in 5/6/7/8? Probably it was because he put more weight on the setae retained on the clitellum even though this is not a valid characteristic of megadriles.

Probably Sims & Easton (1972) took Beddard (1900a: 424) too literally when he described two non-type specimens of *A. mauritianus* from Hong Kong that he likened to *A. morrisi*. The spermathecae of the single types of each: these being in 6 & 7 in *morrisi* and 7 & 8 in *mauritiana*, separate these two taxa regardless of subsequent embellishments. However the addition of the two Hong Kong specimens

may account for the three registration numbers for *mauritiana* types (that were not found in the current study).

Beddard (1892a: 172) was further mistaken when he referred a single worm from Singapore via Kew as being similar to his *P. morrisi* and to his earlier *"Perichaeta ceylonensis*" as there is no such taxon and he probably meant his *Pe. ceylonica* that is now *Megascolex ceylonicus* (Beddard, 1886: 89, fig. 1-3). The single Singapore specimen had intestinal caeca and a gland on the atrium that thus may qualify as a member of the genus *Manus* Blakemore, 2010 currently known only from Japan for type *Pheretima koellikeri* Michaelsen, 1928; thus quite different from *A. morrisi*.

Gates (1939: 454) had a table of setae and GMs in ten Szechwan specimens showing they are usually mid-ventral on 6-8 and paired laterally on 7 less often with only two specimens having GMS on 18 and one of these on 19 too. But, because he footnotes that these all had a pair of markings next to the male pores, they no longer comply with *A. morrisi* and probably represent one or more of its previous synonyms.

The previous broad definition of *A. morrisi* had allowed genital markings very rarely lacking, usually small discs presetal unpaired median in some or all of 5-8 or 6-9 and 18; paired and just median of spermathecal pore lines or more mesially in some or all of 6-9; occasionally two or more in 18 or 19; and almost constantly two just median to each male pore but one pre- and one post-setal. Intestinal caeca simple but (always?) with incised or lobate ventral margin. This is now restricted unless molecular evidence can show that specimens with mid-ventral GMs in 7 & 8 also have the variations as described for subsequent synonyms that are briefly presented below in chronological order.

Past synonyms of *A. morrisi* eligible for restoration progressively in date order

Amynthas pallidus (Michaelsen, 1892) [now restored – see below]

Perichaeta pallida Michaelsen, 1892 (Sept.): 227. From Porto Alegre, Brazil. Berlin types 441, supposedly more than two specimens, missing according to Reynolds & Cook, 1976: 149]. [It has two (or three?) pairs of spermathecae in 5/6/7(/8) and GMs variable in male field and near spermathecal pores, also some mid-ventral too but possibly refering to two different taxa].

Perichaeta amazonica Rosa, 1894: 14. [From Manaus, Brazil. Turin(?) types missing].

Perichaeta sanctijacobi Beddard, 1895b: 239. [From Santiago, Chile. Hamburg type

missing. Specimen lacked GMs but thought similar to *A. morrisi* because it had spermathecae in 6 & 7 but each with swollen diverticulum].

Pheretima pallida : Michaelsen, 1897: 235.

Perichaeta cupulifera Fedarb, 1898: 445, fig. 1. [From Dehra Dun in NW provinces, India. Types from Calcutta Museum? Cf. *A. gracilis* synonymy].

Amyntas pallidus : Michaelsen, 1900a: 24.

Pheretima pallida : Michaelsen, 1900b: 254 (held in synonymy of *P. barbadensis* along with *amazonica, sanctijacobi, cupulifera*).

Pheretima hawayana lineata Gates, 1926: 154; 1931: 384-386, fig. 24 of spermathecae; 1932: 434-435 (!syn. *Pheretima browni* Stephenson, 1912: 273 - obviously a mistake - see *Metaphire californica*). [From Taungyi, Myanmar. Types lost. Gates described this species with spermathecae in 5/6/7 and with characteristic median preclitellar papillae (sometimes missing) and papillae internal to and either side of male pores plus a presetal pair on 19].

?*Pheretima incongrua* Chen, 1933: 270. [From Lin-hai-hsien, Chekiang, China. Types in US National Museum 20175].

?*Pheretima elongata* : Ohfuchi, 1956: 148 [laps. non Perrier, 1872: 124 (= *Polypheretima elongata*)].

?*Pheretima exiloides*: Ohfuchi, 1956: 142 [non Chen, 1936: 288].

Distribution: Introduced to South American and India, probably from China. Its distribution is confused with that of *A. morrisi* s. stricto and subsequenty synonyms.

Diagnosis: Pale yellow-gold but pale brown dorsally (*sanctijacobi* greenish brown). Longest 125 mm by 5 mm with 95 segments. Setae 52-59 in midbody. First dorsal pore uncertain. Male pores widely separated on 18. Typically two pairs of spermathecae in 5/6/7 and GMs variable in male field and near spermathecal pores, also some mid-ventral too but possibly refering to different taxa. Michaelsen gives GMs as: two, three or four papillae particular to each of the male pores. Another pair just behind 18/19, close to each other and to the ventral midline, and two other couples on segment 7 in the ventral-median line. In other examples (different species?) those papillae near the male pores differed and papillae or groups (up to 3) were on the intersegmental furrows of 5/6 and 6/7 or 7/8.

Gizzard occupies 9. Intestine in 14. Caeca from 26 (form not stated). Hearts 11-13. Holandric, metandric. Prostates 18. Spermathecae in 6 and 7 (and sometimes 8?).

Notes: Michaesen's specimens with three pairs of spermathecae in 5/6/7/8 should strictly

be excluded from the definition; they possibly comply with *A. rockefelleri* (Chen, 1933) or some similar taxon. Having markings around the male pores currently disqualifies *A. pallida* as a synonym of *A. morrisi* but unfortunately exact characterization is unavailable without access to the type of either taxon.

Because Michaelsen (1900b: 238, 244, 254) maintained a broadly defined *Pheretima barbadensis* with synonymys: *pallida, amazonica, sanctijacobi* and *cupulifera*, now that *barbadensis* is made synonym of *A. gracilis*, then these latter three should all probably now be accepted as *A. pallidus* synonyms.

P. cupulifera was described with GMs a pair or a single papilla at the edge of the segment (7?) in line with spermathecal pores in 6/7; one worm from several was said to have two median papillae on 7 & 8 (as in *morrisi*); and others had markings near male pores as in Fedarb's figure. The two pairs of spermathecae in 6 & 7 have a diverticulum swollen at the extremity. Fedarb's figure of segments 18-19 (presumably of the what would be the type) is also particularly close to male field of the type of *A. insulae*. However, the author made no mention of the state of the intestinal caeca thus, for the present as in the past, it falls under *A. pallidus* as per Michaelsen (1900b).

Parthenogenetic ***A. incongruus*** (Chen, 1933) as described by Chang *et al.* (2009: 52) from China and Taiwan may now be comparable to degraded forms of *A. pallidus* as may its possible synonym *A. lubricatus* (Chen, 1936) that lacks markings. GenBank COI barcode for *A. inconguus* agrees 98% with *A. morrisi*, A. *aspergillus*, *A. triastriatus* and several other BLAST results, none of these identities confirmed. Other "*A. triastriatus*" agree with *A. tralfamadore* but not other "*A. triastriatus*" while a recent treatise by rather egotistical Chinese workers again fails to mention any of my work, likely adding yet more confusion, rather than enlightenment, to the mad mix.

[Note: *A. pallidus* was restored as a valid taxon by Blakemore 2014, see - http://opuscula.elte.hu/PDF/Tomus45_2/2_Op_Blakemore_London_Museum_worms.pdf].

Amynthas insulae (Beddard, 1896)

Fig. x

Perichaeta insulae Beddard, 1896: 205, fig. 2. [From Hong Kong. Type BMNH 1904:10:5:86 inspected by Gates, 1939: 454, by Sims & Easton, 1972: 180 and

herein. Michaelsen (1910 or 1927) has Hong Kong specimen mislabeled "*P. insularis*"].

Pheretima insulae : Michaelsen, 1900: 276.

Amynthas insulae : Sims & Easton, 1972: 237 (*morrisi* group); Blakemore, 2008.

Material Examined: BMNH 1904:10:5:86. Labels in jar state: "*Perichaeta insulae* (Beddard) (Type?) 1904:10:5:86 Hong Kong Beddard Coll^{n}"; "Perichaeta insulae Hong Kong" in Beddard's hand; "Probably the type of *Perichaeta insulae* Beddard but now = *P. morrisi*" in Gates' hand?; "fide G.E. Gates". Jar contains one previously dissected specimen in good contition with a separate vial containing a single spermatheca.

Distribution: Hong Kong, China.

Diagnosis (from Beddard and current inspection of type): 103 mm with 95 segments. Clitellum 14-16. GMs are described as papillae paired "*near the anterior margin on viith segment*" but figured by mistake on the 8th, here correctly shown on segment 7; eight on 18 (but misfigured by Beddard compared to the current sketch) and a single papilla on 19 on "*left side of the body*" (actually on rhs as per current sketch). Glands correspond to the GMs internally on 18. Pharyngeal glands to the sixth segment. Septa 4/5-7/8 thin, those immediately after gizzard thicker. Seminal vesicles in 11 and 12. Prostates racemose. Spermatheca in 6 & 7 (opening to 5/6/7) with shortish, unswollen diverticulum as sketched. Intesine from 15, caeca in 27 newly found to be ventrally serrate/incised as sketched.

Notes: It seems that *A. insulae* should be maintained separatedly from both *A. morrisi* and *A. pallidus* based on its serrate intestinal caeca and shorter, thin spermathecal diverticulum. Sims & Easton (1972: fig. 1H) claim a similar 'complex' caecum in *A. morrisi* from a non-type specimen that they fail to identify but this has yet to be confirmed. Furthermore, the precise arrangement of its GMs on 7 and 18-19 certainly differ from *A. morrisi* proper whilst helping to define this taxon.

DNA (barcodes): From ENA (July, 2014) (http://www.ebi.ac.uk/ena/data/search?query=amynthas%20morrisi) and GenBank:

1/."Four new earthworm species of the genus Amynthas Kinberg (Oligochaeta: Megascolecidae) from Hainan and Guangdong Provinces, China" Jiang J., Sun J., Zhao Q., Qiu J. (2014) |KF021247.1 Amynthas morrisi voucher Sichuan, China SC201006-03 cytochrome c oxidase subunit I (COI) gene, partial cds; mitochondrial. : Location: 1..700
AACAAATCATAAAGATATTGGAACCCTATATTTTATTTTAGGAATTTGAGCTGGGATAAT
TGGTGCAGGAATAAGACTCCTTATTCGAATTGAACTAAGACAACCAGGATCATTCCTCGG

AAGAGATCAACTATATAACACAATTGTAACTGCACATGCATTTTTAATAATTTTCTTTCT
TGTAATACCAGTATTTATTGGGGGATTTGGAAATTGGCTACTACCCCTAATACTAGGTAC
TCCAGATATAGCATTCCCACGTCTAAATAATATAAGATTTTGGCTACTACCACCTTCTCT
CATTTTACTGGTAAGATCTGCAGCCGTAGAAAAGGGTGCGGGGACAGGGTGAACAGTATA
TCCCCCACTCGCAAGAAATATCGCCCATGCTGGTCCTTCAGTCGACTTAGCAATCTTCTC
GCTCCACTTGGCCGGGGCCTCATCCATTTTAGGGGCCATCAACTTTATTACTACAGTAAT
TAACATACGATGATCCGGATTACGGTTAGAACGAATTCCACTATTCGTATGGGCAGTGGT
AATTACAGTAGTACTTCTTCTCCTATCACTTCCAGTATTAGCGGGAGCAATCACAATACT
ACTAACAGACCGAAACCTAAACACATCATTCTTTGACCCAGCTGGAGGAGGTGATCCAAT
TCTATATCAACATCTATTCTGATTTTTTGGTCACCCTGAA

2/. Shen (2012) “Three new earthworms of the genus Amynthas (Megascolecidae: Oligochaeta) from eastern Taiwan with redescription of Amynthas hongyehensis Tsai and Shen, 2010.” J. Nat. Hist. 46:2259-2283(2012);JX290441-5 eg. |JX290441.1 Amynthas morrisi voucher mor1 cytochrome c oxidase subunit 1 (COI) gene, partial cds;mitochondrial. : Location:1..658
AACCCTATATTTTATTTTAGGAATTTGAGCTGGAATGATTGGTGCAGGAATAAGACTACT
TATTCGAATTGAACTAAGACAACCCGGATCATTCCTTGGAAGAGACCAACTATATAATAC
AATTGTAACTGCACATGCATTTTTAATAATTTTTTTTCTTGTAATACCAGTATTTATCGG
AGGATTTGGAAATTGACTACTACCCCTAATACTAGGTACTCCAGATATAGCGTTTCCACG
ACTAAATAATATAAGATTTTGACTACTACCGCCATCACTTATTTTACTAGTGAGATCTGC
AGCCGTAGAAAAGGGTGCGGGAACAGGATGGACAGTATACCCCCCACTCGCAAGAAATA
T
TGCCCACGCTGGGCCGTCAGTAGACTTAGCAATTTTCTCACTCCACTTAGCCGGAGCCTC
ATCTATTTTAGGAGCTATCAACTTTATTACTACAGTAATTAATATACGATGATCTGGACT
ACGTTTAGAACGAATCCCGCTATTCGTATGAGCAGTAGTAATTACAGTAGTACTTCTTCT
CCTATCACTTCCGGTATTAGCGGGAGCAATTACAATACTACTAACAGATCGAAACCTAAA
TACATCATTCTTTGATCCTGCAGGAGGGGGGGACCCAATCCTATATCAACACCTATTC

3/. "Molecular phylogeny and systematics of Japanese pheretimoid earthworms (Oligochaeta: Megascolecidae)." Minamiya et al. Submitted (JAN-2010)
AB542516-8 from Okinawa eg: AB542516.1 Amynthas morrisi mitochondrial COI gene for cytochrome oxidase subunit 1, partial cds, isolate: Amor-1242. : Location:1..637
GGAATTTGAGCTGGAATAATTGGTGCAGGAATAAGACTCCTTATTCGAATTGAACTAAGA
CAACCAGGATCATTCCTCGGAAGAGATCAACTATATAACACAATTGTAACTGCACATGCA
TTTTTAATAATTTTCTTTCTTGTAATACCAGTATTTATTGGGGGATTTGGAAATTGGCTA
CTACCCCTAATACTAGGTACTCCAGATATAGCATTCCCACGTCTAAATAATATAAGATTT
TGGCTACTACCACCTTCTCTCATTTTACTGGTAAGATCTGCAGCCGTAGAAAAGGGTGCG
GGGACAGGGTGAACAGTATATCCCCCACTCGCAAGAAATATCGCCCATGCTGGTCCTTCA
GTCGACTTAGCAATCTTCTCGCTCCACTTGGCCGGGGCCTCATCCATTTTAGGGGCCATC
AACTTTATTACTACAGTAATTAACATACGATGATCCGGATTACGGTTAGAACGAATTCCA
CTATTCGTATGGGCAGTGGTAATTACAGTAGTACTTCTTCTCCTATCACTTCCAGTATTA
GCGGGAGCAATCACAATACTACTAACAGACCGAAACCTAAACACATCATTCTTTGACCCA
GCTGGAGGAGGTGATCCAATTCTATATCAACATCTAT

4/. Huang, et al. (2007) "Identifying earthworms through DNA barcodes." Pedobiologia 51:301-309(2007): |EF077578 – EF077590 Amynthas morrisi voucher 06-252 from China cytochrome c oxidase subunit I (COI) gene, partial cds; mitochondrial. : Location:1..602
GCTGGGATAATTGGTGCAGGAATAAGACTCCTTATTCGAATTGAACTAAGACAACCAGGA
TCATTCCTCGGAAGAGATCAACTATATAACACAATTGTAACTGCACATGCATTTTTAATA
ATTTTCTTTCTTGTAATACCAGTATTTATTGGGGGATTTGGAAATTGGCTACTACCCCTA
ATACTAGGTACTCCAGATATAGCATTCCCACGTCTAAATAATATAAGATTTTGGCTACTA
CCACCTTCTCTCATTTTACTGGTAAGATCTGCGGCCGTAGAAAAGGGTGCGGGGACAGGG
TGAACAGTATATCCCCCACTCGCAAGAAATATCGCCCATGCTGGTCCTTCAGTCGACTTA
GCAATCTTCTCGCTCCACTTGGCCGGGGCCTCATCCATTTTAGGGGCCATCAACTTTATT
ACTACAGTAATTAACATACGATGATCCGGATTACGGTTAGAACGAATTCCACTATTCGTA
TGGGCAGTGGTAATTACAGTAGTACTTCTTCTCCTATCACTTCCAGTATTAGCGGGAGCA
ATCACAATACTACTAACAGACCGAAACCTAAACACATCATTCTTTGACCCAGCTGGAGGA
GG

5/. >HY14|Amynthas gracilis - Jeju1 from Blakemore *et al*. 2014 (in press).

GAGCAGGAATAAGACTACTTATTCGAATTGAGCTCAGACAGCCGGGATCGTTTCTGGGAAG
AGATCAATTATATAATACAATTGTAACAGCTCATGCATTCGTAATAATTTTCTTTCTAGTAATA
CCAGTATTCATTGGTGGATTTGGAAACTGACTACTACCTCTAATGCTGGGTACACCAGACAT
AGCATTTCCGCGGCTTAATAATATAAGATTTTGGCTACTCCCCCCGTCACTTATCTTACTAGTA
AGATCCGCGGCCGTTGAAAAGGGGGCGGGAACTGGATGGACAGTATATCCCCCGCTGGCA
AGAAATATTGCACATGCTGGTCCATCAGTAGATCTAGCAATCTTCTCACTACACTTAGCAGG
GGCATCATCTATTCTTGGGGCCATTAACTTTATTACAACTGTAATTAATATGCGATGATCTGGA
TTACGGCTAGAGCGAATCCCCCTATTTGTATGGGCCGTAGTAATTACTGTAGTACTTCTACTAT
TATCTCTACCTGTACTAGCCGGAGCTATTACTATACTATTAACAGATCGAAACCTTAACACAT
CATTCTTTGATCCCGCTGGAGGTGGAGACCCTATTCTATATCAACACCTATTT
Blast result: *Amynthas gracilis* (AB542489.1 & 542491.1 from Japan), 100%.]

July, 2013 **BLASTn** and **megaBLAST** comparisons of:

1/. vs. 2/. max Identities = 601/658 (91%)

1/. vs. 3a/. AB542516 max Identities = 636/637 (99%)

1/. vs. 3b/. AB542517 max Identities = 580/637 (91%)

1/. vs. 3c/. AB542518 max Identities = 580/637 (91%)

1/. vs. 4/. max Identities = 601/602 (99%)

3a/. vs. 4/. Id = 600/602 (99%).

1/. vs. 5/. = 520/614 (85%).

2/. vs. 5/. = 525/614 (86%)

4/. vs. 5/. = 85%

I.e., both *morrisi* haplotypes different to *A. gracilis*.

Thus it appears that genetic data differ so at least some (if not all) identifications must be incorrect for *A. morrisi* and it is beholden on Chinese/Taiwan and Japanese workers to confirm their species and/or vouchers against the types.

Summary –

- *Amynthas morrisi* is restricted to its lectotype and the original type-description; efforts should be made to relocate this missing type and to analyse DNA samples, preferably from Penang topotypes that comply morphologically. Only then can its relation to other *A. morrisi* group members be determined.
- *Amynthas barbadensis* is restricted to the lectotype which is specimen "b"that now complies with prior *A. gracilis* as its junior synonym.
- *A. mauritianus*should be provisionally maintained restored although there is little to separated it from quadrithecal forms of prior *A. gracilis*. Certainly it is separate from the restricted *A. morrisi*.
- The other previous synonyms of *morrisi* that were questioned by Blakemore (2003, 2007, 2008) revert to the earliest name which is

Amynthas pallidus that is also restored as per its original description. Whether species such as *A. insulae* and *A. cupuliferus* actually agree may again be settled by progressive DNA analysis of taxa representatives in original homelands or from their transported populations.

- It is noteworthy that DNA analyses currently posted on GenBank show that samples identified by different authors under the name *A. morrisi* represent different taxa – none of which may be the same as the current concept – thus there is justification for establishment of a species-complex and for urging further studies on actual species identities and boundaries of these in their Asian homeland and in translocated populations.

See description of *Amynthas talus* below for further comparison of *A. morrisi* group.

Amynthas papilio (Gates, 1930)

Fig. 29 by Chang *et al.*, 2009.

Pheretima papilio Gates, 1930: 316; Gates, 1972: 205. [From San Hlan, Myanmar. Types none (or in India?)].

Non *Pheretima papilio* : Ohfuchi, 1956: 140 - Misidentification according to Gates (1972: 205) cf. *A. glabrus* (Gates, 1932).

Amynthas papilio papilio : Sims & Easton, 1972; Blakemore *et al.*, 2006: 228; Chang *et al.*, 2009: 66, fig. 29

Diagnosis: Spermathecal pores near 5/6 in anterior of 6. Male pores small slits each within a large logitudinally elliptical porophore in region of 17-19 (not really seminal grooves cf. *A. glabrus*), other genital markings absent. Intestinal caeca, small, simple or incised.

Distribution: Myanmar (Gates, 1972: 188), Taiwan. Reports from Ryukyu Islands by Ohfuchi (1956) have been disputed by Gates (1972) and Chen & Chuang (2003).

Remarks: Gates (1961, 1972) divided *A. papilio* into three subspecies: ***A. papilio papilio***, *A. papilio insignis* (= ***A. papilio vesperitilio*** Blakemore, 2006 nom. nov.; non *insignis* Michaelsen, 1921), and ***A. papilio hiulca***. The specimens from Taiwan were identified by Chen & Chuang (2003) as *A. papilio papilio*, whose previously known locality was Myanmar. As the Taiwan specimens were collected from the grass fields in the school campus, and human disturbed environments associated with urbanization, Chen & Chuang (2003) speculated that *A. papilio* is an exotic species introduced recently to Taiwan perhaps with vegetations from the Southeastern Asia.

Amynthas papulosus (Rosa, 1896)

Perichaeta papulosa Rosa, 1896: 525, figs. 14-16. [Type locality Balighe, Sumatra. Types in Genoa: 44034; other material in British Museum (Sims & Easton, 1972: 181)].

Pheretima papulosa var. *sauteri* Michaelsen, 1922: 26. [Type locality Dorf Kosempo, Taiwan. Types in Leiden: 1814].

Pheretima composita Gates, 1932: 430. [Type locality Kengtung. Types none].

[?*Pheretima rockefelleri* Chen, 1933: 238, fig. 17. Type locality Linhai, Chekiang Province, China. Types in U.S. Nat. Museum, 20176 – see **Remarks** below].

Pheretima papulosa : Michaelsen, 1900: 291; Gates, 1972: 206 (syn. *papulosa sauteri*, *composita*, *rockefelleri*).

Amynthas papulosus : Easton, 1981: 56 (syn. *papulosa sauteri*, *rockefelleri*); Shih *et al*. 1999: 436, tab. 1 (syn. *papulosa sauteri, rockefelleri* and accepts presence in Kyushu and Kinki, Japan from Kobayashi, 1941 reports).

[?*Pheretima hsinpuensis* Kuo, 1995: 187, fig. 3. [From Taiwan. Types in Taiwan?]. Name originally misspelt "hsinpuesis" (sic laps. corr. *hsinpuensis*); synonymized with *A. papulosus* as then constituted by Blakemore (2003: addendum) and subsequently with *A. rockefelleri* (Chen, 1933) by Shen, Tsai & Tsai (2003): *Endemic Species Research*, 5: 41-44].

Amynthas multipapillatus Hong, 2017. Laos. **Syn. nov.**

Note: *Amynthas savanakhetanus* (Thai & Samphon 1988) should perhaps be returned as a separate species, although it sub-sp status links it to *A. papulosus*.

Diagnosis: Spermathecal pores ca. 0.25 circumference apart postetal in 5/6/7/8. Male pores superficial on segment 18. Genital markings transverse rows of small pre- and post-setal on 6,7-9 and 17-19. Intestinal caeca simple. Size range 45-78 mm.

Distribution: Sumatra (Indonesia), Burma (=Myanmar), Thailand, Japan (Kyushu and nearby Yakushima), China, Taiwan, south-east Asia (e.g. Vietnam, Laos). Gates (1972: 207) questions Ohfuchi's (1956) report of *P. papulosa* var. "*sauteria*" (sic) from the Ryukyus but Tsai *et al.* (2000: tab. 1) appear to accept it.

Habitat: ?

Behaviour: ?

Length: 45-100 mm.

Width: 3-5 mm.

Segments: 96-119.

Colour: White.

Prostomium: Epilobous.

First dorsal pore: 12/13 (11/12 in *rockefelleri*).

Setae: Numerous, ca. 50-66 per segment.

Nephropores: Not reported.

Clitellum: Annular 14-16, setae sometimes present ventrally in 14-15,16.

Male pores: Superficial on 18 ca. 0.25 circumference apart.

Female pores: Single on 14.

Spermathecal pores: In 5/6/7/8 ca, 0.25 circumference apart.

Genital markings: Small discs in pre- and post-setal transverse rows in 7-9, 17-19; (stalked glands correspond internally).

Septa: 5/6-7/8 strong, 8/9/10 aborted.

Dorsal blood vessel: Single.

Hearts: 10-13.

Gizzard: In 8-9.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): 16, caeca simple in 27-22.

Nephridia: Meroic.

Male organs: Testes/funnels in 10 and 11 in sacs; seminal vesicles in 11 and 12.

Ovaries: In 13 as usual.

Prostates: Racemose glands in 16-21, duct muscular looped.

Spermathecae: Three pairs, duct slender, tapering, as long as ampulla; diverticulum stalk shorter and thinner stalk is zig-zagged somethat to elongate seminal chamber (bulb).

Gut contents: ?

Remarks: *Amynthas papulosus* is similar to *Amynthas gracilis*, they are mainly separated on the distribution of genital markings, and the male porophores that in *A. papulosus* seem variable as originally shown as simple and superficial but either large circular discs (Taiwan = *A. rockefelleri*) or crescentic areas (Myanmar), or surrounded by deep furrows (China = *A. rockefelleri*). *Amynthas papulosus sauteri* was distinguished by location of caeca from 29 extending forward to 26 in a single specimen that may have been abnormal according to Gates (1972: 207).

Gates (1972: 199) said that his *P. malaca* Gates (1936: 429) nom. nov. pro *P. maculosa* Gates, 1933, is similar to *A. papulosus* except for its extra two pairs of spermathecae; it may also have copulatory pouches and therefore qualify for *Metaphire*.

Genbank COI mtDNA from Thailand identified as *A. papulosus* (KU565201) agrees 100% with (KF205464), an "*Amynthas sp.*" from "China: Yunnan".

Blakemore in Blakemore *et al*. 2006: 228 said: "Gates (1972: 207) thought that the parthenogenetic *rockefelleri* morph (lacking prostates and sometimes with defective spermathecae) was only distinguished by quantitative differences, but recently Shen *et al.* (2003) disputed their earlier inclusion in *A. papulosus* of *A. rockefelleri* and retained both taxa also suggesting *A. hsingpuensis* is synonym of the latter." It thus seems that *A. rockefelleri* is a valid taxon from China with *A. hsingpuensis* from Taiwan its synonym.

The status of *A. papulosus* and its synonym *A. papulosus sauteri* in Japan is currently unresolved due to conflicting reports: Kobayashi (1941) in a series of papers claimed *A. rockefelleri* but these were possibly misidentifications for *A. gracilis* and it is more likely that Ohfuchi's (1956) *A. papulosus suteri* refers to some new or known taxon. Most recent syonymys of *A. gracilis* from China and Laos include two names from Hong (2017). The Japanese record is only retained since the revision of *A. papulosus* by Shih *et al*. (1999: 436, tab. 1) states "*Pheretima papulosa sauteri* (= *Amynthas papulosus*)" and appears to accept Kyushu and Kinki reports of *A. rockefelleri* from Kobayashi (1941) as actually being *A. papulosus*; and Tsai *et al.* (2000: tab. 1) appear to accept Ohfuchi's (1956) report of *A. p. sauteri* (= *A. papulosus*) from the Ryukus. Further research is yet required.

Amynthas phaselus (Hatai, 1930) and sub-species

See: Blakemore, R.J. (2018). *Amynthas phaselus phaselus* and *A. phaselus maculosus*. *The IUCN Red List of Threatened Species* 2018: https://dx.doi.org/10.2305/IUCN.UK.2018-1.RLTS.T118817515A118818075.en. This species is nominally distributed from Hokkaido through Honshu to Kyushu, Shikoku and Tsushima Islands, Japan (Easton 1981). It is reported from Korea: Jeju and Dagelet Islands; and on the Russian Kuril Islands (Blakemore 2012a, 2012b, 2013a, 2013b). China is possibly included if *Pheretima mutica* Chen, 1938 is a synonym, as noted by Blakemore (2003, 2012b, 2014), however this name on the Genbank database from "China" has DNA that does not comply (https://www.ncbi.nlm.nih.gov/nuccore/?term=Amynthas+phaselus pers. obs. Sept., 2017). It seems the Japanese synonym, *A. tamurai* (Kobayashi, 1938), may warrant separate restoration and so too the Korean *A. kamitai* (Kobayashi, 1934) with a tentative

report from Kyushu (Dr Y. Sugi - sky.geocities.jp/yasuakisugi1221/WormTaxonomy/4AmyMetaAll.pdf Oct., 2017).

[*Amynthas pingi* (Stephenson, 1925) (now = *A. carnosus*).

Fig. 2.13**a** *Amynthas pingi* spermatheca. [After Stephenson (1925); Chen (1933 Fig. 15) is more detailed).

Fig. 2.13**b** *A. pingi* ? from Shiga – (as checked against types by Blakemore, 2013.).

Pheretima pingi Stephenson, 1925: 891, text fig. 1 (of testis sac), plate II fig. 7 (of a probably parasitised spermatheca). [Type locality Nanking, China. Lectotype in London, BMNH 1924:11:29:5 inspected by Blakemore, 2013 and found same as *A. carnosus*]; Michaelsen, 1931: 11; Stephenson, 1931b: 55; Chen, 1933: 228, fig. 15 (?non Gates, 1935: 14; nec Gates: 1943: 103?); Chen, 1936: 298 (syn. *fornicata*); Gates, 1939: 465 (examination of types); ?Gates,1943: 103; ?Ishizuka, 2001: 82, fig. 46 (mislabeled "*Pheretima pingi* Chen, 1936") – looks exactly the same as *P. carnosa* in fig. 9 of Chen (1959) so probably so. See Blakemore (2013) for full review.

?*Pheretima fornicata* Gates, 1935: 9; Chen, 1936: 296 (examintation of type); Gates, 1939: 434. [From Tatsienlu, Tibet (and Sichuan?). Types in US Natl. Mus. no. 20099]; it lacks genital markings but is otherwise stated to be similar to *P. hongkongensis* Michaelsen, 1910: 107 that has only a pair of small marking immediately median to male pores on 18.

Amynthas pingi: Sims & Easton, 1972: 235 (*diffringens*-group); Blakemore, 2002: 183; 2003: 19; 2006: 271.

Taxonomic Note: Chen, 1936: 274 (when describing *P. pingi chungkingensis*, that now probably merits elevation to species level, remarked that *P. pingi* was probably a synonym of *P. carnosa*). Gates (1939: 436) doubted the statement by Chen (1936: 298) that *P. fornicata* "*is probably identical with* P. pingi *Steph*.", perhaps because it lacks genital markings; nevertheless, there is similarity that merits investigation. Kobayashi (1936) included *P. pingi* in synonymy of his corrected *P. carnosa*, this now supported.

Diagnosis: ***Amynthas pingi pingi*** with spermathecal pores in 5/6/7/8/9 [***A. pingi chunkingensis*** (Chen, 1936) with spermathecal pores in 6/7/8/9]. Genital markings paired ventrally on 8, 9 and 18 and 19. Intestinal caeca simple from 27.

Distribution: Nanking, plus one (dubious?) specimen from Kuatun, Fukien at 3000-5000ft (Gates, 1943) and another dubious report from Japan (see Blakemore, 2003).

Abundant in Nanking constituting about 30% of worms there [Stephenson (1931: 56) on information from Dr Chen]; found with *Metaphire houlleti*.

Habitat: ?

Behaviour: ?

Lengths: 140-340 mm.

Width: 5-9 mm.

Segments: 126.

Colour: Dark slate dorsally, paler ventrally; clitellum darker.

Prostomium: Broad closed epilobous.

First dorsal pore: 11/12 or 12/13.

Setae: Numerous, usually 35-60 per segment; those of segments 2-9 enlarged.

Nephropores: Not reported.

Clitellum: Annular 14-16, no setae visible.

Male pores: On 18 on elliptical porophore.

Female pores: Single on 14.

Spermathecal pores: 5/6/7/8/9 ca, 0.3 circumference apart at posterior of translucent areas in posteriorly in 5-8.

Genital markings: Paired discs just median to lines of male and spermathecal pores, or sometimes shifted more ventrally, presetal on 8, 9, 18 and 19; and typically with at least a postsetal pair on 18. Dr Chen informed Stephenson (1931: 56) that in the Nanking specimens there are usually three pairs of papillae in the neighborhood of the male pores: two pairs on 18 and one pair on 19 (Stephenson's original account has only one pair behind the setal zone of 18, thus, either the anterior or the posterior pair of papillae on segments 18 and 19 may be absent). Stephenson (1931: 56) added that the anterior and posterior pairs are not infrequently shifted towards the median line (in 20 out of 50 worms), in which case the two pairs of papillae on 8 and 9 are shifted inwards to a corresponding extent and this would be similar, if not identical, to the position typically found in *A. carnosus*.

[Chen (1933: 231) for *P. pingi* allows papillae rarely absent, one to three pairs (occasionally up to five pairs) usually placed around male pores: two pairs on segment 18 in front and behind the setae and one pair on 19 in front of setae, the post-setal pair on segment 18 often close to male pores while the ante-setal pair on both segments either laterally or medially. Often paired on 8 and 9, those on 8 placed either ante- or post-setally if only one pair present, or on both sides of the setal line if two pairs

present; one or occasionally two pairs on 9 generally placed ante-setally (seldom present post-setally on 9 and ante-setally on 10) – these papillae paired either latero-ventrally or medio-ventrally. These marking distributions thus easily overlap those of *A. carnosus*].

For Gates (1943: 103) "*aside from those just in front of the spermathecal pores*" there were three pairs of markings on 18: one pair lateral to each male pore and two pairs median to the male pores, one presetal and one postsetal. However, this single specimen from Kuatun, Fukien at 3000-5000ft, was doubted to be *pingi* accorging to Chen (as noted above) and, moreover, Gates himself questioned its separateness from *diffringens* (= *corticis*).

Septa: 5/6-7/8 strong, 8/ 9 lacking (or membranous), 9/10 thin, 10/11 and 11/12 considerable. Lymph glands large, paired from 19 posteriorly.

Dorsal blood vessel: Single.

Hearts: 9-13.

Gizzard: Single in 8-9.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): 19; caeca simple smooth in 27.

Nephridia: Meroic.

Male organs: Testes/funnels in 10 and 11 in sacs; seminal vesicles large in 11 and 12.

Ovaries: In 13 as usual.

Prostates: Racemose glands in 17-19, duct muscular.

Spermathecae: Four pairs, the ampulla oval, duct almost as long; the diverticulum from near body wall reached to half the height of ampulla with slender stalk and wider seminal chamber. Several tubercules were described by Stephenson, these are probably parasitic artefacts (as also suggested by Gates, 1939: 468).

Gut contents: ?

Remarks: After Blakemore (2013) found to be junior synonym of *A. carnosu*s.

The characteristic tubercules on the spermathecal ducts are not nephridial and inspection of the letotype shows they are due merely to *Monocystis* infestation, thus this species may well have been in the ambit of *Amynthas corticis* that often has these (see *A. corticis* figures herein). If this is the case, then the relatively large size, retention of prostates, and its abundance in Nanking may be indicative of a possible endemic range for sexually biparental populations of the various parthenogenetic morphs that are now widely distributed around the world. However, it was deemed synonymous with *A.*

carnosus (Goto & Hatai, 1899) that appears especially similar, as was suggested by Chen (1935: 275; 1936: 275) and as concluded by Kobayashi (1936) and Ohfuchi (1937). This last option is now a most likely outcome and these two taxa probably require merging. Slight reticence is due to slightly larger size in *A. pingi* and supposed later onset of intestine origin and septal glands. It is possible, nevertheless, that *Amynthas chungkingensis* be retained as a separate species, this dependent on access and inspection of types (indeed suggested as per Gates, 1939)].

Amynthas rechingeri (Cognetti, 1909)

Pheretima rechingeri Cognetti, 1909: 1; Cognetti, 1909: 311 [Samoa. Types in Turino: 189 and Vienna: 4762].

Amynthas rechingeri : Sims & Easton, 1972; Blakemore, 2004; 2007.

Diagnosis: *Amynthas* with spermathecal pores in 5/6/7/8; genital markings as a series of papillae on segment 18; intestinal caeca simple.

Distribution: Samoa (?native) and undoubtedly introduced to Hawaii.

Remarks: Publication by Cognetti (1909) in *Boll. Mus. Torino* **24(604):** 1.

Amynthas robustus (Perrier, 1872)

– now with *A. masatakae* (Beddard, 1892) and *A. tralfamadore* Blakemore, 2012 separated off.

Fig. 2.14a after Perrier's original *P. robustus* figs. 67-68.

[Fig. 2.14b Beddard's *P. masatakae* Lectotype – this taxon restored from synonymy in *A. robustus* by Chuang & Chen (2002) and supported herein and in Blakemore (2012) with inspection of types and in Blakemore & Lee (2013)].

Fig. 2.14c modified after Y. Sugi's *A. robustus* from his website (Dec. 2008) – but probably this concept is the same now as the restored *A. masatakae* synonym.

Perichaeta cingulata (part cf. *P. darnleiensis*): Vaillant, 1867: 234 (err. non Schmarda, 1861).

Perichaeta robusta Perrier, 1872: 112, figs. 67-68. [No type designation but types in Paris Museum: AE587 (A721) from Île de France (Mauritius), three specimens collected by Mr Desjardins, probably in 1835; plus AE588 from Manille (Manila,

P.I.), one specimen collected by B. Barrot in 1852]. In the title Perrier 1872: 112 says "syn. *P. cingulata* L.V. pars.".

?[*Perichaeta masatakae* Beddard, 1892: 761. Types listed as BMNH: 1904:10:5:91-2 actually 1904:10.5.912-913 (pers. obs.) from "*Japan*" collected by "*Mr Masatake Rokugo*"; Michaelsen (1903) gives locality as Kamakura, probably for its junior synonym *campestris*.

Amyntas masatakae: Beddard, 1900: 632 (syn. *campestris*).

Pheretima masatakae: Kobayashi, 1937: 337, fig. 2, 1938: 137; Ohfuchi, 1938: 62, figs. 6-7, 1956: 132, fig. 11.

Amynthas masatakae : Chuang & Chen, 2002: 73, fig. 1; cf. Wang & Shih, 2010 in an unpublished conference paper have syn. *A. triastriatus* (Chen, 1946: 97) from China and reported from Vietnam, but maintain *A. robustus* separately – this study based on COI analyses but, as far as the information provided, not from the types; cf. Chen *et al*. (2010) who note closeness of *triastriatus* to *gracilis* and misidentification of *A. robustus* as *A. benignus* (Chen, 1946) by Huang *et al.* (2007) again based on COI but again not on types. This taxon now (Blakemore, 2012e) given separate species status – see Blakemore (2012e) with inspection of types and in Blakemore & Lee (2013). Note: Sims & Easton (1972: 181; 244), Reynolds & Cook (1976: 134), and Easton (1981: 56) mistake Beddard's species as "*mastakae*", while Michaelsen (1900: 282) has it correctly, as here, as *P. masatakae* – named, presumably, after donator Mr Masataka Rokugo – cf. *M. rokugo*. This taxon recently restored by Blakemore (2012, 2013)].

?[*Perichaeta campestris* Goto & Hatai, 1898: 67, fig. From Kamakura, Japan. No types. Here it is restored, it is unlikely to be a synonym of *A. robustus*, cf. *P. parvicystis*].

Amyntas löhri Michaelsen, 1899: 12. [From Shi-hui-yao near Wuchang, Hupei. Types in Hamburg V351, mostly dried out and adherent but compliant to dwarfed and parasitized *robustus* according to Gates (1939: 499)].

?[*Perichaeta parvicystis* Goto & Hatai, 1899: 18, figs. 8, 8a, 8b. From Uwajima (Ehime-ken, Shikoku) and Oarai (Ibaraki-ken, Honshu). No types. See also its separate description below as "*Amynthas parvicystis*". Described with spermathecal pores in 6/7/8 – but this maybe a mistake (as for *P. vesiculata* and *P. carnosa*!) and, if so, possibly a junior synonym of *A. masatakae*, it is retained

separately here as *species incertae sedis* as described below].

Megascolex robustus: Vaillant, 1889: 76 [this name miscited by Reynolds & Cook (1976: 164) as a separate species].

?[*Pheretima lauta* Ude, 1905: 405 (429?, 464?). [Locality Foochow. Types in Hamburg Museum: 10472]. Gates (1939: 482) seems to imply, while some later identified specimen may actually be *robustus*, the type of *lauta* = *aspergillum*!?

Pheretima lauta : Chen, 1933: 282, fig. 26 (?syn. *siemsseni* Michaelsen, 1931: 17; *fokiensis* Michaelsen, 1931: 19 – note some authors mistakenly cite Michaelsen, 1930 or 1931: 574, but I have seen the original description and it is directly after that of his *siemsseni*, unless he published twice); Chen, 1933: 282, fig. 26 (??syn. *siemsseni* Michaelsen, 1931: 17; *fokiensis* Michaelsen, 1931: 19); Gates, 1939: 420 (inspected type 10472, as part of *aspergillum*); Ohfuchi, 1956: 155 (syn. *siemsseni*, *fokiensis*). Cf. *A. aspergillum*!].

?Pheretima zavattarii Cognetti, 1909: 1; Cognetti, 1909: 310. [From Madagascar. Types unknown].

Pheretima ornata Gates, 1927: 20. [Type locality Lashio. Types in the Indian and US National Museums].

Pheretima corrugata Chen, 1931: 131; 1933: 278 (non *P. corrugata kulingiana*). [Szechuan. Types in Smithsonian Institution, but Gates (1939: 341) says one paratype was *diffringens* (= *corticis*)].

?Pheretima sheni Chen, 1935: 38. [From Hong Kong. Types in US National Museum]. [Lacking spermathecae cf. *A. illotus*].

Pheretima robusta: Michaelsen, 1900: 299 (syn. *cingulata* part.); Chen, 1935a: 36-37; 1936: 271 [syns. *siemssen* (part), *fokiensis, lauta, loehri*, *corrugata*; non *P. corrugata kulingiana* nec *P. aspergillum*]; Kobayashi, 1940: 390; Chen, 1946: 136 (syn. *corrugata*); Gates, 1935: 15; Gates, 1937: 364 (inspected material labeled *mandhorensis*); Gates, 1939: 473 [syns. in part! *löhri* (= *loehri*), *corrugata, lauta, masatakae*]; Ljungström, 1971: 27 (syn. *campestris, corrugata, lauta, masatakae*); Chen, 1959: 13, fig. 17 (paired mid-ventral markings in 18 as present or absent); Gates, 1972: 216 [syn. *ornata*, ?*zavatarii* (sic lapsus pro *zavattarii*), ?*sheni* plus other unlisted names], 1982: 62 (synonyms mentioned only via citation of Gates' own publications).

Amynthas robustus: Sims & Easton, 1972: 234 ; Easton, 1981: 56 (syn. *mastakae* [sic lapsus pro *masatakae*], *campestris* Goto & Hatai, 1898 [non Lee, 1952], *lauta*,

corrugata); Blakemore, 2003: 7, 2006: 229, 2008 (syns. as above); Chang *et al.* 2009: 76, fig. 34.

Taxonomic Notes: Ljungström (1971) details his concept of the taxonomy and distribution of this peregrine species. Gates (1972: 218) said that ten names were in synonymy of *robusta*, but he did not list them; only four were listed by Easton (1981) but it is possible that *P. campestris* Goto & Hatai, 1898 probably does not belong if the spermathecal pores are much less than 0.5 circumference apart, and, moreover, its GMs certainly differ being post-setal pairs in 7 & 8 and 17-19 approximately as wide as the spermathecal pores in 7/8/9. In the current author's Japanese studies, specimens apparently complying, but with extra spermathecae in 6/7/8/9 have been identified perhaps indicative of (parthenogenetic?) polymorphism (cf. *P. kamakuraensis* Goto & Hatai, 1898). Gates (1972: 217) also remarked that the British Museum specimen 1904:10.5.1401 labeled *P. mandhorensis* from West Indies is a misidentification or mislabeling for *Amynthas robustus*. Michaelsen's *A. loehri* is possibly synonymous with *A. robustus* according to Chen (1936: 271; 1939: 473) and Gates (1939; 1972), or with parts of *Metaphire californica* according to Chen (1931: 137). Although initially confident, Chen (1935a: 36-37) expressed some doubt about his earlier inclusion of *siemsseni* and *fokiensis* in *P. robustus*. More work is required by Chinese colleagues to resolve this.

There is some possibility that *robustus* may merit recombination in *Metaphire* as its male pores may be strictly non-superficial, at the same time, *masatakae* appears now to merit re-elevation to seperate species status in *Amynthas*.

Diagnosis (with *A. masatakae* characteristics in braces for removal and *A. tralfamadore* described briefly under that taxon's name below): *Amynthas* with paired spermathecal pores ca. 0.5 circumference apart in (6/)7/8/9 or, rarely, absent. Male pores ca. 0.44 circumference apart. Genital markings paired presetally behind spermathecal pores in 8 & 9 with another midventral pair on 18, never mid-ventral and unpaired in 18 (for the previous *A.masatakae* synonyms, with one or, characteristically two pairs in the latter location just median to the male pores, one pre- and one post-setal). Intestinal caeca simple (with short ventral lobulations in *masatakae*). Size 33-180 by 2-9 mm but usually >85 by 4 mm upwards in mature specimens (Chen, 1935a; Gates, 1972).

Distribution: Mauritius, Philippines, Myanmar, Laos (Thai & Samphon, 1991), India, China, Taiwan, [?Korea including Cheju (= Quelpart) Island but this for *A. masatakae*,

plus Japan and Okinawa (Easton, 1981)]; Madagascar (Michaelsen, 1907 and Ref.); ?Brazil claimed as *P. aspergillum* from Sao Paulo by Righi (1967) recently confirmed as such (Ref.); a record of *A. robustus* from West Indies is probably a mislabeled specimen according to Gates (1972: 217). A probable homeland is in China (Gates, 1972: 12, 217). Reported from Nice (France) by Benham (1890: 235). Not reported from Australia.

Locality: not found in current studies (cf. *A. masatakae*).

Habitat: In fertile or rocky soil in jungles and manured gardens.

Behaviour: ?

Length: 33-180 but usually >85 by 4 mm upwards in mature specimens (Chen, 1935a; Gates, 1972); 150-180 mm by 6 or 7 mm wide (Perrier).

Width: 2-9 mm.

Segments: 79-136.

Colour: Slate to dark reddish brown, often paler at setal equators.

Prostomium: Open epilobous.

First dorsal pore: (10/)11/12(/13).

Setae: Numerous, usually 30-80 per segment.

Nephropores: Not reported.

Clitellum: Annular 14-16.

Male pores: Superficial on 18 on a thickened disc [described by Chen (1933: 36) as about a third or more of the circumference apart and by Chen (1935: 36-37) as "[Setae] *between male pores 16-20. Male pores about 0.3 or a little more of circumference apart, each on a smaller tubercle, usually retracted in a shallow skin fold, immediately medially to it (not in front of but on setal line) is found a small papilla connecting internally with a stalked gland; both tubercle and papilla surrounded by 4 or 5 circular ridges. Two close but separate papillae situated medioventrally in front of seta, usually raised as two nipples with independent circular folds*"]. Note that male pores are superficial but GMs may protrude giving appearance of male pores as in *M. californica*.

Female pores: Single on 14.

Spermathecal pores: In (6/)7/8/9 ca. 0.5 circumference apart intrasegmental and often just in front of small discs (i.e., not on the actual discs which are sucker-like GMs with glands corresponding internally).

Genital markings: As small, paired circular to elliptical discs, ca. 1 intersetal interval wide, in some or all of 7-9, 18: often one in and one just behind and slightly median of

each spermathecal pore; less often one just in front of a spermathecal pore (?never mid-ventral and unpaired). Gland correspond internally as just noted above.

Septa: 5/6-7/8 strong, 8/9/10 lacking.

Dorsal blood vessel: Single.

Hearts: 10-13.

Gizzard: in 8-9.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): 15 or 16; caeca simple in 27-22 often with short ventral lobulations; typhlosole present.

Nephridia: Meroic.

Male organs: Testes/funnels in 10 and 11 in sacs; seminal vesicles large in 11 and 12; pseudovesicles in 13-14.

Ovaries: In 13.

Prostates: Large racemose, duct muscular.

Spermathecae: Duct shorter than ampulla, with diverticulum from near body wall with slender stalk and wider seminal chamberm, the whole diverviculum being almost twice as long as the ampulla (Perrier, 1872: fig. 68; cf. Gates, 1935: fig. 10); stalk not zig-zagging. GM gland often under diverticulum.

Gut contents: ?

Remarks: *Amynthas robustus* (Perrier, 1872) is believed to be a temperate zone species originally from China with an acquired range that, despite a few wider records, is unlikely to be expanded by colonization of tropical lowlands (Gates, 1972). It is morphologically similar to *Amynthas taitensis* (cf. *A. aeruginosus*), *A. esafatae*, and quadrithecal morphs of *A. gracilis*. At one time it was thought synonymous to *Amynthas aspergillum* but Perrier's figures (Perrier, 1872: figs. 67-68 of *robustus* vs. figs. 71-72 of *aspergillum*) should be sufficient to separate them (*A. aspergillum* is described above).

Gates (1972: 217) commented that athecal *Pheretima sheni* Chen, 1935 may be referable to *P. diffringens* (= *Amynthas corticis*) or to *P. robusta* so, to allow for this latter option, the choice of "(*rarely absent?*)" is given in the diagnosis and key above.

Easton (1981: 56) had *Amynthas lautus* (Ude, 1905) as a synonym of *A. robustus* (Perrier, 1872), but this requires confirmation as Tsai *et al*. (2000: 286) disagree, based on inspection of (all?) Taiwanese specimens. On the other hand, Chen (1933: 282-288, fig 26) thought *Ph.* (*Ph.*) *seimsseni* Michaelsen 1931: 17 and *Ph.* (*Ph.*) *fokiensis* Michaelsen, 1931: 19 were synonymous with *P. lauta* Ude; and

later Chen (1936: 271) and Chen (1946: 136) placed his *P. corrugata* in synonymy with *P. robusta*. Chen (1936: 271) deliberately excluded his *P. corrugata kulingensis* Chen, 1933: 278 subspecies – which presumably qualified for elevation to species level (in *Amynthas*).

Perichaeta parvicystis was described by Goto & Hatai (1899: 18) with spermathecal pores in 6/7/8 – but maybe this is a mistake (as for *P. vesiculata*) – otherwise it agrees tolerably well wit the restored *A. masatakae*.

Being an earlier described species, and possibly having parthenogenetic variability in spermathecae and genital markings, allows the *A. robustus* name to collect several later names for specimens with two (or none or three?) pairs of spermathecae. It seems the diagnosis may overlap somewhat with *A. corticis* spp.-complex, thus some reservation is anticipated until their true identities are determined from DNA analysis of types.

Amynthas rodericensis (Grube, 1879)

Fig. 2.15 *Amynthas rodericensis* from Samford (a) ventral view with (b) prostates and (c) spermathecae in position on the (d) dorsum; (e) intestinal caeca and "lymph" glands, (f) posterior.

Perichaeta rodericensis Grube, 1879: 554. [Type locality Rodriguez. Type in the Breslau Museum(?), other material in the British Museum; Reynolds & Cook (1989: 30) cite a syntype in Wroclaw University Museum, Poland: 586; Gates, (1937) inspected probable BM paratypes].

Perichaeta dyeri Beddard, 1892a: 157, Pl. IX, figs. 2, 8, Pl. X, fig. 1. [From Kew Gardens, UK. Types BMNH: 1904.10.5.33-36]; Beddard, 1900a: 623 (syn. *sinensis, monilicystis, shimaensis* – this last one doubtful).

Perichaeta sinensis Beddard, 1892a:158, Pl. IX, figs. 3,5, Pl. X, figs. 2-4, 7,8. [From Grenada via Kew. Types BMNH: 1904.10.5.152-6, 161]; Beddard, 1896: 208.

?*Perichaeta trinitatis* Beddard, 1896: 206. [From Trinidad. Type BMNH 1904:10:5:170. Genital markings absent. Beddard did not record location of spermathecal pores, only that the spermathecae were in 6-9, later when describing *A. alexandri* Beddard (1901) said the pores were less dorsal than in *trinitatis*].

Perichaeta monilicystis Michaelsen, 1892: 251, fig. 28. [From Berlin Botanical garden.

Types Berlin 2157, missing].

Pheretima rodericensis: Michaelsen, 1900: 299, 318 (syn. *dyeri*, *sinensis*, *monilicystis*, ?*trinitatis*); Gates, 1937: 365 (syn. *sinensis*); 1954: 238; 1972: 218; 1982: 63 (syn. *dyeri*).

Amynthas rodericensis: Sims & Easton, 1972: 235; Easton, 1982: 729; Sims & Gerard, 1985: 132 (syn. *dyeri*, *sinensis*).

Diagnosis: *Amynthas* with paired spermathecal pores dorsally located in furrows 5/6/7/8/9. Genital markings usually paired in 17/18 and/or 18/19 (or absent).

Distribution: Lily House of Kew Gardens, UK (Beddard, 1892), St Petersburg, Russia (in plantpot, Michaelsen, 1903: 8) USA (e.g. first recorded by Gates, 1954 from Florida), Caribbean and Latin America (eg. Venezuela, French Guyana, Jamaica, Puerto Rico, Barbados, Martinica, Trinidad, Surinam, Dominican Republic, Guatamala etc. from Gates, 1954; Brown & Fragoso, 2007), Diego Garcia (Sims, 1971), Australia, Pacific Islands, e.g. Samoa (Vargo, 1999), Southeast Asia (e.g. Myanmar, Vietnam), European interception from Italy and from glasshouses e.g. St Petersberg, Russia (Michaelsen, 1903: 9) and Denmark on Skov-og Naturstyrelsen database as an introduced taxon (www.skovognatur.dk/natur/invasive_arter/images/introarter.xls Jan., 2007), Lagos, Nigeria, Cote d'Ivoire, Swaziland and South Africa, Sao Tome (Ref.) and the Indian Ocean region, e.g. Mauritius (type locality), Madagascar (eg. Michaelsen, 1916). From Australian, previously reported from Christmas Island south of Java (Gates, 1935b: 94), from Qld. (Easton, 1982) and from interception (Gates, 1982). Michaelsen (1903: 99) reports it from "*Japan (Shima)*" that is most likely 志摩市 (*Shima-shi*) a former district that is centred on Shima-city in Mie Prefecture central Honshu – this record has been overlooked by subsequent authors (eg, Gates, 1972, 1982; Easton, 1981) until now.

An amateur report in 1997 of *A. rodericensis* in several Australian states after "A survey of the earthworm fauna of urban and agricultural soils in Australia" – was one of only two pheretimoids claimed from the whole continent. Quite ridiculous!

Despite Asian origin of this taxon, *A. rodericensis* is not yet known from Korea nor much of southeast Asia (from literature searches and lack of pers. obs.).

Locality: Tully, Byfield, Samford, Closeburn, Narang, Brookfield and Taringa suburbs of Brisbane, all in Qld; Lismore and Harwood, NSW - new records (Blakemore, 1994).

Habitat: Under pasture, riverbank under litter; under sugar cane at Harwood NSW.

Behaviour: Active escape and lashing response to handling, exudation of bright yellow

coelomic fluid and autotomy of 'tail'.

Length: 85-130 mm.

Width: 3.5-5 mm.

Segments: Ca. 100±8.

Colour: Deep red-brown dorsum with green/blue iridescence and dark blue mid-dorsal line (the sites of the dorsal spermathecal pores are paler), pale ventrum, clitellum buff.

Prostomium: Closed (furrowed?) or open epilobous.

First dorsal pore: 11/12.

Setae: Numerous.

Nephropores: None found.

Clitellum: Annular 14-16.

Male pores: Wide apart on small raised circular porophores on 18i.

Female pores: Single, central within small circular depression on 14.

Spermathecal pores: Dorsally four pairs in 5/6/7/8/9.

Genital markings: Large spherical flat sucker-like pads anteriorly and/or posteriorly and mesially to male pore centred in 17/18 and 18/19 (rarely 19/20). In some specimens one of the four genital pads may be absent and quite frequently specimens with either just the anterior pair or, perhaps more usually just the posterior pair (i.e., on 18/19).

Septa: To 7/8 strong, 8/9/10 lacking.

Dorsal blood vessel: Single continuous on pharynx.

Hearts: 10-13.

Gizzard: Muscular and spherical in 8-9.

Calciferous glands: Absent but oesophagus dilated in 10-12.

Intestine origin (caeca, typhlosole): 15; caeca simple 27-25; (typhlosle present).

Nephridia: Meroic.

Male organs: Testes/funnels in 10 and 11; seminal vesicles in 11 and 12.

Ovaries: Compact in 13.

Prostates: Racemose in 16-21, muscular ducts form hairpin loops.

Spermathecae: Large sub-spherical ampulla with short duct from which thin (irregularly zigzag-looping) diverticular duct branches reaching as far or further than tip of ampulla with subspherical, iridescent ental bulb(s).

Gut contents: Soil and organic matter.

Notes: The genital markings usually form two pairs although often only the posterior pair in 18/19 are found or these plus one on either side in 17/18. Gates (1972) states that

they may appear first in 18 then grow to locally obliterate furrows 17/18 and 18/19.

Remarks: *Amynthas rodericensis* is distinctive in the prominent markings around male pores and the dorsal location of its spermathecal pores in 5/6-8/9. Several other species with dorsal spermathecal pores are: *Polypheretima pentacystis* (Rosa, 1891) from Seychelles (Mahe) and Madagascar (Noddi-Be); *Po. voeltzkowi* (Michaelsen, 1907) from Comoros and Vanuatu; *Po. gatesi* Easton, 1979 from New Guinea; *Po. patae* Easton, 1979 from New Guinea; polythecal *Metapheretima carolinensis* (Michaelsen, 1910) (syn. *Pheretima garama* Gates, 1958: 8) from Caroline Isls. (where it is probably not endemic according to Michaelsen, 1934: 15) and Sumatra (North Lampung); *Amynthas sulcatus* (Gates, 1932) known only from the Burmese type-species, *A. youngi* (Gates, 1932) also from Myanmar and from Yunnan, China; and metandric *Amynthas sladeni* Lee, 1981 from Vanuatu (pores 5/6-8/9). Further species, noted by Stephenson (1924), are *Metaphire brinchangensis* (Stephenson, 1932) from Malayan Penisula (pores 7/8/9), *Metaphire notizusa* (Michaelsen, 1928) from Java (pair 6/7), and *Metaphire michaelseni* (Ude, 1925) from Borneo (single, mid-dorsal in 8/9). Also *Amynthas mujuensis* Hong & Kim, 2002 from South Korea (paired in 6/7/8); *Amynthas chaishanensis* (?= *M. formosae*) and *Metaphire hengchunensis* (James, Shih & Chang, 2005) from Taiwan (paired 5/6-8/9 or 6-9?); *Metaphire cruroides* (Chen & Hsü, in Chen, Hsü, Yang & Fong, 1975) from China (pores in 5,6,7); *Metaphire thecodorsata* (Chen, 1933) from China (pores in 5,6,7); *Metaphire ?dorsobitheca* (Thai & Huynh in Thai, Do & Huynh, 1992) from Vietnam (6/7/8/9 with spermathecae doubled); and possibly *Pheretima ?dorsomonotheca* Thai and Samphon, 1988 from Laos; *Planapheretima ? plumatomusculata* (Thai, 1982) from Vietnam (3 or 4 pairs in 5/6/7?); and *Polypheretima voeltzkowi* (Michaelsen, 1907) from Comoros (spermathecae paired in 5 or absent).

Several reports of *A. rodericensis* (e.g. from some Australian states and from Japan) are by non-specialists and appear to be unverified, probably because either the lack of obvious spermathecal pores ventrally means they are assumed to be dorsal, or because use of limited 'identifiers' or guides – such as Sims & Gerard (1985; 1999) that only list British species with few Megascolecids/pheretimoids – that tend to force the novice's choices into the most obvious, but often wrong, taxonomic conclusion.

Amynthas talus Blakemore, 2014.

Amynthas "morrisi group" (Sims and Easton, 1972) : Blakemore, 1994: 353, fig. 1.27.

Amynthas talus Blakemore, 2014.

Fig. 2.12a *Amynthas morrisi* species-group (*A. talus*), Mt. Cotton specimens: (a) ventral view with (b) prostate, (c) intestinal caeca, (d) spermathecae; (e) second specimens with blood vessels showing in 10 and with (f) prostate and (g) spermathecae *in situ*. Differs from some descriptions of *A. morrisi* proper by the markings on 18 being outside male pores; described by Blakemore (1994) as a possible new species – given MS name of "*Amynthas talus*" in 1995 ANIC register.

Locality: University of Queensland farm at Mt Cotton (27°53'S,153°14'E), collected by RJB, 19.I.1993 from pasture and under *Albizia spp.* in reddish soil; other material collected by D. Mercer in 1975 and A. Wilkie in 1992 from the same site. Numerous mature and immature specimens those lodged in ANIC (RB.95.1.1) listed as H and P1 other, supposedly still in collection at Queensland University. Contemporary details of the Mt Cotton site soils and vegetation are provided by Gutteridge (1990).

Etymology: From Latin *talus* for dice, after the GMs looking like dots on face of a dice.

Habitat: Under pasture; sandy soil of lower creek bank almost in gravels of water line, also in moister clay under trees and shrubs at 0-20 cm depth.

Registration No.: ANIC: RB.95.1.1.

Behaviour: Two specimens (one with 135 segments) had autotmy of posteriors. Much ejected mucus adhered to dorsum in several specimens (see note below). Vigorous lashing escape response on being handled.

Lengths: Current 75-100 mm (cf. 45-120 Gates for *morrisi*).

Width: 3-4 mm.

Segments: 122-156 body cylindrical anteriorly but tapering and becoming more trapezoid posteriorly, some secondary annulation in anterior, deep furrows in posterior. Segment 10 is wide and semi-transparent: paired ventral blood vessels show through.

Colour: Dark brown anterior and dorsum (but setal auriolae paler), paler ventrum, clitellum buff, after clitellum dark mid-ventral line. In formalin, a uniform buff but with deep puce clitellum.

Prostomium: Parallel open epilobous, often compressed.

First dorsal pore: 11/12 and then 12/13 but not on clitellum, although present subsequently and continuously to posterior.

Setae: Numerous ca. 40-50 per segment, ventral and dorsal gap slight if at all; only faintly retained ventrally on clitellum; typically no setae between male pores but in two specimens two larger (penial?) setae seen midventrally between male pores (figured).

Nephropores: None visible.

Clitellum: Annular 14-16, furrows obliterated or faintly retained.

Male pores: 0.3 circumference apart on slightly raised equatorial porophores surrounded by several faint concentric grooves with markings nearby (see Genital markings).

Female pores: Single, central on 14 in small countersunk dish or in lateral groove.

Spermathecal pores: Two pairs in 5/6 and 6/7 lateral, ca. 0.4 circumference apart with slightly tumid lips concealed in furrows.

Genital markings: Variable as small mid-ventral paired (occasionally single, or quadruple) presetal discs in 5-7 or 6 and 7, and often a postsetal pair in 6 (and occasionally 5); plus always one pair mid-ventral and presetal on 18 between male pores, and often another pair postsetally. Also immediately lateral to the porophores on 18 a pair (may be doubled) of small raised papillae anteriorly and posteriorly; or one or both of the anterior pair may be absent. In sub-adults only the male pores are present, papillae and genital markings are lacking.

Septa: 4/5/6-7/8 getting progressively thicker and displaced posteriorly, with tendons reaching to succeeding segmental walls; 8/9 membranous or absent, 9/10 aborted; 10/11-14/15 getting progressively weaker with tendons persisting.

Dorsal blood vessel: Single continuous to pharynx in 4.

Hearts: Weak in 7 then strong in 10 (from dorsal vessel), 11-13 (from supra-oesophageal vessel). Supra-oesophageal vessel from region of 10/11 to 14. Ventral blood vessel bifurcated under gizzard from 10. In 5 and 6 numerous small blood vessels appear clustered together.

Gizzard: Large, tubular to bell-shaped and muscular with evenly spaced longitudinal blood capillaries occupying space between 7/8 and 9/10.

Calciferous glands: Small oesophageal pouches which appear pink due to blood capillaries and have internal lamellae present in 10 (annular) 11-13 (ventrally pouched) and 14 (weakly annular). These outgrowths of the oesophageal wall are easily deformed and in section the walls are thick and squamous but calciferous granules were not seen. (Beddard also found the oesophagus in segments 10-14 to be thickened and whitish in *A. morrisi*).

Intestine origin (caeca, typhlosole): Oesophageal valve in 14 or 15 opens into intestine in 15 or 16; caeca simple and extending from 27 to 24. At the region of the caecal origin, a large single lamelliform dorsal typhlosole commences.

Nephridia: Meroic, from 4-7 numerous tubules are obvious on the posterior septa,

further anteriorly they are much larger, almost tufted; from segment 8 posteriorly micronephridia are equatorial on the body wall.

Male organs: Testes/funnels in membranous testis sacs in 10 and 11. Segments 7-14 are filled with white coagulum, but seminal vesicles (and pseudovesicles?) can be distinguished in 10-13 but not in 9.

Ovaries: Rather small pair ventrally from anterior septum of 13 as flattened palmate or clustered egg strings with oviducts in the posterior septum.

Prostates: Racemose, bi- or tri- or multi-partite, from 17/18-19/20, large muscular ducts in single loops. Vasa deferentia enter the glands near the junction with the duct.

Spermathecae: Two pairs in 6 and 7 with long slender duct widening to sub-spherical (or flattened) ampulla, ectally a single diverticulum branches with a thin stalk and dilated bulb which is either elongate or lobular. The curved diverticula do not reach to the apices of the ampullae. Iridescence was generally not seen in the bulbs of the diverticula although some stalks possibly had an internal sheen; the ampullae were often filled with clear coagulum. In one specimen the spermathecae were noticeably heteromorphic: the ampullae of the anterior pair were flattened with small, bulbous (iridescent) diverticula on short stalks, whereas the posterior pair had larger, elongate diverticular bulbs filled with an opaque coagulum.

Gut contents: Fine soil and few pieces of organic debris suggesting a geophagous diet but possibly selective.

Notes: Pharyngeal mass extends back to 5/6 obscuring the nephridial form. Internally, small, squat glands were associated with the genital markings, which were not clearly stalked but rather flattened to the body wall and were invested in a coagulum of sticky mucus (their product?). Mucus was also ejected onto the dorsal surface of several of the specimens and may be a natural defence against predators or desiccation, here activated by preservation. In the coelomic cavity the mucus may be a defence against parasites, e.g. Gates (1972: 203) reports spores and nematode eggs being discharged in coagulum through the most anterior dorsal pores in specimens identified with *A. morrisi*.

Remarks: Queensland specimens described here comply with the *Amynthas morrisi* species-group of Sims & Easton (1972) for which *A. morrisi*, as diagnosed above, is the representative species. Considerable variation in the distributions of genital markings appears permissible within this species-complex, however, the current specimens are somewhat unusual in having more than 100 segments, closely paired anterior markings but with male field markings lateral of the male pores, and a typhlosole that is well

developed rather than rudimentary (cf. Gates' description). It is therefore possible that they more closely resemble some other of the 30-40 nominal taxa within the *A. morrisi*-group but no exact match has been found as yet from searches of the literature after twenty years.

I here reduce the possibilities to about 20 candidates, in order of priority: *morrisi* Beddard, 1892; *insulae* Beddard, 1896, *lalangi* or *silvestris* both by Michaelsen, 1923; *choeinus* Michaelsen, 1927; *incongruus* Chen, 1933; *alutus* Chen, 1936, *hainanicus, puerilis, sinuosus,* all by Chen, 1938; *gravis* or *sapinianus* Chen, 1946; *loveridgei* Gates, 1968; *nanulus* Chen & Yang, 1975 (only 51 mm long); *parvus* Chen & Zhifang; either of Thai's (1982) species, or to one of Hong & James', 2001: *draconis, naejangensis, piagolensis, taebaekansis*. These can be compared with some of quadrithecal synonyms of *A. gracilis*.

A species that perhaps comes closest is *Amynthas instabilis* Qiu & Jiang, 2014 just published in Jiang *et al*. (2014) from Hainan and Guangdong, itself comparable to parthenogenetic *A. incongruus* (Chen, 1933) from Taiwan and China and to *A. tripunctus* (Chen, 1946) from China. It differs in having only a few setae (0-2 stated, 0-3 figured) between the male pores and lacks the mid-ventral markings there (although it too has paried markings lateral to the male pores, in the holotype at least). This may also serve to indicate the likely region of origin for *A. talus*.

A possibly related species is *Amynthas loveridgei* (Gates, 1968) found on St Helena and in the USA (e.g. Florida, Georgia, Minnesota) that was distinguished from *A. morrisi* by having more segments than *A. morrisi* and genital markings that possibly differ. Its spermathecae varied in number, but a similarity in Gates' (1968) account is of there being copious sticky mucus in the body cavity which interferes with dissection, as with the specimens here. Lacking marking other than those immediately median to the male pores, it is possible that *A. infuscuatus* Jiang & Sun, 2014 is the same as this, or the same as *A. pallidus*. Also similar is *A. endophilus* Zhao & Qiu, 2013 that is said to lack markings despite these being shown as a pair mid-ventral on 18 in their fig. 1.

Amynthas tralfamadore Blakemore, 2012

This molecular species from Incheon (introduced), Jeju Island and from China (according to Genbank as *Amynthas sp., A. triastriatus* or *A. robustus* but these also differ from the same named on Genbank COI). It is separated from both *A. masatakae*

and *A. robustus* for cogent points as presented by Blakemore (2012) and in Blakemore & Lee (2013). These two publications stand true in their priority and reason. Here is objective and definitive holotype DNA result, and some other sad misidentifications:

>WO2 NIBR 19th March, 2012 ***A. tralfamadore*** **Holotype** – BLAST best is 94% A. robustus or A. triastriatus – Note: NEED TO REVERSE COMPLEMENT in MEGA6.
GTGTTGGTATAGGATTGGATCTCCCCCTCCTGCTGGATCAAAGAATGATGTAT
TGAGGTTTCGATCTGTTAGTAATATGGTAATTGCCCCTGCCAGTACAGGTAGG
GACAATAGTAATAGTACTACAGTGATTACTACTGCTCACACAAATAGTGGGAT
TCGTTCTAGACGTAACCCAGATCATCGTATGTTAATTACTGTTGTGATAAAGTT
AATAGCTCCAAGAATTGACGAGGCACCTGCAAGATGAAGTGAGAAAATTGC
AAGGTCTACTGAAGGACCGGCATGTGCTATATTTCTTGCTAAGGGTGGGTAA
ACTGTTCAACCTGTGCCAGCCCCCTTTTCTACCGCGGCAGATCTTACCAATAA
AATTAATGATGGCGGGAGTAGTCAAAATCTTATGTTATTTAATCGAGGGAACG
CCATATCTGGGGTTCCAAGTATTAGGGGTAGTAACCAGTTTCCGAATCCACCA
ATAAATACTGGCATTACTAGAAAGAAGATTATTAAAAATGCATGTGCTGTTAC
AATTGTATTATATAGCTGGTCCCTACCAAGGAAGGATCCAGGTTGTCTTAACT
CAATACGAATAAGTAGTCTTATTCCTGCACCAATTATTCCTGCTCAAATTCCTA
GAATAAAGTATAGGG
Blastn (Sept., 2017) = 100% Amynthas sp. KT252955 from South China, 99% A. robustus KT429019 from "China", 99% A. triastriatus KT252962 from South China and KX467191 from a park near Hong Kong!! Also 94% A. robustus AB542533 from Osaka and AB542532 from Tokyo.

WO35 **Nogeyama** ***A. masatakae*** 5/5/2012 collected by RJB and T.J. Tansy - megaBLAST=99-100% "A. triastrianus" from China or "A. robustus" from Japan - these misidentifications, as expected! WO35 vs. w28b Identities=657/657 (100%), i.e. A. masatakae confirmed from Jeju. QED. WO35 vs. w29 Identities=614/657 (93%), i.e. different taxa (=*A. tralfamadore*). WO35 vs. w30 Identities=617/657 (94%), i.e. different taxa (=*A. tralfamadore*).
GGAACCTTATACTTTATCCTGGGAATTTGAGCAGGAATAATTGGTGCAGGAAT
AAGACTACTTATTCGTATTGAATTAAGACAACCGGGATCCTTCCTTGGTAGAG
ACCAACTATATAATACAATTGTAACAGCACATGCATTCTTAATAATCTTCTTTCT
AGTAATGCCAGTATTTATTGGTGGATTCGGAAACTGGCTACTGCCCCTAATAC
TTGGAACCCCAGATATGGCGTTCCCCCGATTAAATAACATAAGATTTTGACTA
CTTCCACCATCCCTAATTTTATTAGTAAGATCGGCCGCGGTAGAAAAAGGAGC
GGGCACAGGTTGGACAGTTTACCCACCCCTAGCAAGAAATATAGCACATGCC
GGCCCTTCAGTAGACCTTGCAATTTTCTCACTCCATCTTGCAGGTGCCTCATC
AATTCTTGGAGCTATTAACTTTATCACAACAGTAATTAACATGCGATGATCTG
GGCTACGTCTAGAACGAATCCCACTATTTGTATGAGCAGTAGTGATCACCGTA
GTACTATTATTATTATCCCTACCTGTACTGGCTGGGGCAATTACCATATTACTAA

CGGATCGAAACCTTAATACATCATTCTTTGACCCAGCAGGAGGGGGGGACCC AGTTCTATACCAACACCTATT.

Shamefully, some particularly ignorant people have tried to suppress this name under *A. masatake* as revived by Blakemore (2012) for no good reason except that: "*Blakemore (Blakemore 2013a: p. 30 and p. 35) reported sympatry between "A. masatakae" (= clade A) and "A. tralfamadore" (= clade B). Thus, we conclude that clade A and clade B are intraspecific clades of the same species and A. tralfamadore should be considered a junior synonym of A. masatakae*" (https://bdj.pensoft.net/article/119599/)! So, because wildbeeste and zebra occur "sympatrically" in Africa they must be the same species?!! Ridiculous time-wasters who also whinge about "*insufficient sampling*" and that COI sequences "*of A. masatakae and A. tralfamadore published by Blakemore (2012c), Blakemore (2013a) and Blakemore and Lee (2013) were not available in GenBank, but could be found as part of the text in the paper*." So what? These authors are most welcome to commission my full surveys and to pay for my time to upload to Genbank or, rather than whinge about it, they can do it themselves. *Amynthas tralfamadore* is thus retained as a valid taxon separate from *A. masatake* as was originally proposed, not least on its genetic difference that is proper for parthenogenetically degraded morphs! That the morphology is similar was already noted, yet these deniers seem unable to understand that species may differ in many characteristics – such as behaviours – that are not immediately accessible but are nevertheless real. Please stop wasting our time! Ditto for sympatric gnus or zebras as same species; only an idiot would say it; otherwise, move on.

The deniers also falsely claimed that Blakemore had "*suggested the provenance of both species from Jeju*" whereas, in truth, Blakemore (2012d) had only claimed "*the NIBR specimen's probable provenance from Jeju*", not a species' origins from there!

Amynthas zebrus (Benham, 1896/7)

Perichaeta zebra Benham, 1896: 442. [Type BMNH:1896:9:30:3]. [Sometimes as 1897].

Amyntas zebrus : Michaelsen, 1899: 73.

Amynthas zebrus : Michaelsen, 1900: 313.

Diagnosis: *Amynthas* with simple intestinal caeca, one pair of spermathecae in 7/8 and a pair of papillae either side of male pores and another pair anteriorly between male pores. Body purple (banded), 200 mm by 6 mm with 120-146 segments.

Distribution: *Amynthas zebrus* is reported from "*Pic von Bonthain*" south Celebes (type locality) and as a native from New Guinea (Edwards & Grubb, 1982; Standon, 1988; Sillitoe, 2003: 88 – after Rose & Wood, 1980?).

Remarks: Its endemic range is either quite wide, or it has been misidentified, or it is introduced to one or other(s) of these places.

Amynthas spp. incertae sedis:

Perichaeta tricystis Perrier, 1877 from Brazil as noted by Beddard (1895: 402) and considered *nomen dubium* by Michaelsen (1900) but Moreira (1903) thought it is what is now *Amynthas gracilis*

Perichaeta dicystis Perrier, 1877 from Brazil as noted by Beddard (1895: 402) and considered *nomen dubium* by Michaelsen (1900) but Moreira (1903) thought it what is now *Metaphire californica*.

Perichaeta viridis Schmarda from Sri Lanka as noted by Beddard (1895: 402).

Perichaeta burlariensis Bourne as noted by Beddard (1895: 403).

Genus ***Begemius*** Easton, 1982

Begemius Easton, 1982: 713; Blakemore, 1994; 2004; 2007.

Dignosis: Perichaetine. Gizzard in 8 and intestinal caeca originating in 25. Male pores superficial, combined with pores of racemose prostates on 18. Lateral crescentic markings usually associated above and/or below the male pores. Metandric.

Distribution: New Guinea and (introduced or neoendemic to) northern Queensland.

Remarks: *Begemius* has several recorded representatives in New Guinea, its evolutionary centre, and those found in northern Australia are possibly neoendemic (see Easton 1982, Fig. 1). Although Dyne & Wallace (1994: 59) described *Begemius* as an endemic genus they then (page 62) state it is '**neoendemic**' saying:

> "Begemius *is most likely* ***neoendemic****, having close affinities to Indo-Pacific pheretimoids. It is the only known genus of earthworm common to Australia and New Guinea. The pheretimoid genera are of* ***oriental origin****, some having radiated comparatively recently in the Indo-Pacific (Easton, 1979). Australian* Begemius *are known only from the far north Queensland and their precursors are assumed to have gained entry to Australia via New Guinea through Quaternary land-bridges*". [My bolding].

My view also tends to follow that of Easton (1982), the author of the genus, who described it as indigenous to both New Guinea and northern Queensland, and said that this genus has more in common with exotic pheretimoids, therefore its progenitors are almost certainly **not** Australian. However, as the full complement of species and distributions in both New Guinea and northern Australia are unknown, categorical statements cannot be made although distribution of known members in Australia: i.e., highly restricted and/or and coastal, is typical for introduced species.

In conceited contrast, Jamieson (2000) claimed it an "*endemic*", "*native*", or "*indigenous Australian genus*" of "*Australian origin*" and (p. 77) disputed its inclusion within non-natives by Blakemore (1999) saying "*there is no reason to believe that it is not native to Australia*" and that "*The Gatesian higher classification* [sic!] *used by Blakemore is emended to conform to evidence from molecular analysis given in this monograph*". However, it is a fabrication to say that Blakemore (1999) used Gates' classification (for example Blakemore, 1999 quite rightly returns *Pontodrilus litoralis* to Megascolecidae, unlike Gates who included it in his mistaken "Gatesian" concept Acanthodrilidae) and, moreover, the molecular analysis given in that monograph rather inconveniently showed *B. queenslandicus* to group **only** with exotic *Amynthas rodericensis* and *Perionyx excavatus*, thereby giving every reason to support entirely Blakemore's earlier contention.

Mechanisms for transportation may be readily evidenced in the numerous pre-historic cultural and trade exchanges between the Torres Strait islands and the land masses to the north and south. Thus I believe relatively recent (in last few 1,000s years) is more likely mode of transportation and possible radiation.

Easton referred eight species to this genus although their affinities, again, are clearly closer to the oriental pheretimoids than to truly native Australian genera. Easton (1982:15) noted the resemblance with the acaecate species in the Papuan genus *Metapheretima* and remarked that the precise caecal origins of a few other metandric species are not known, implying that this genus may be expanded. Refer to Easton (1982: 16) for a key to species. Two species are rather uncertain: ***Begemius cyclops*** and ***B. monoperus*** both by Cognetti (1911) were redescribed by Cognetti (1912) who said the intestinal caeca in the monotypic specimens originated in 26 or were indeterminate due to maceration, respectively. As neither species type had a clitellum, it seems they were also immature or regressed.

Begemius queenslandicus (Fletcher, 1886)

Fig. 2.16 *Begemius queenslandicus* from Mt. Lewis (a) ventral view with (b) prostate and (c) spermathecae.

Perichaeta queenslandica Fletcher, 1886b: 962, fig. 6; Beddard, 1895a: 407. [Type locality Barron River District, North Queensland. Syntypes AM, W2399].

Amynthas queenslandicus : Beddard, 1900: 643; Sims & Easton, 1972: 237; Lee, 1981: 546.

Pheretima queenslandica : Michaelsen, 1900: 297; Michaelsen, 1917: 34.

Begemius queenslandicus : Easton, 1982: 721, figs. 2e, 3d; Blakemore, 1994; 2006, 2007.

Distribution: Cape York Peninsula, Qld..

Locality: Mt. Lewis, near Cairns, Qld. (Easton, 1982).

Habitat: "*dry soil near the summit in tropical rainforest*".

Registration No.: Queensland collection. (The specimen re-described here is probably one inspected by Easton (1982) since the label concurs with one of his listed entries).

Length: 45-165 mm.

Width: 2.5-7 mm.

Segments: 86-125, some secondary annulation, body spherical.

Colour: Colourless in alcohol.

Prostomium: Open epilobous.

First dorsal pore: 10/11-12/13.

Setae: Small and numerous per segment; ventral series partly visible on clitellum.

Nephropores: None seen.

Clitellum: Annular on 14-16, but impinged by male field ventrally in 16/17, furrows and setae faintly retained.

Male pores: Superficial, 0.25 circumference apart on raised equatorial porophores with a depressed setal region intervening on 18 between crescentic lateral grooves; ventral furrow 17/18 somewhat obscured by general tumescence.

Female pores: Minute, single or closely paired and central within small circular depression on 14.

Spermathecal pores: Four pairs in 5/6/7/8/9 0.25 circumference apart.

Genital markings: Paired mainly presetal small disks with opaque centres just ventral to spermathecal pore line in some or all of 5-11, 17 and 19-23. Those adjacent to the male pores are marginally larger, the posterior pairs appear to converge slightly. Internally small glands associated with the markings sessile on the body wall.

Septa: 5/6-7/8 thickened; 8/9 weak and compressed on 9/10; 10/11-13/14 only moderately thickened thereafter thin.

Dorsal blood vessel: Single, continuous onto pharyngeal bulb in 4 and 5.

Hearts: Smaller commissurals noted for 7, and hearts 9,10-12, supra-oesophageal vessels not detected.

Gizzard: Large, muscular in 8 (appearing to occupy all of 9 and 10).

Calciferous glands: Oesophagus dilated and vascularised with internal lamellae in 10-13, these swellings decrease in size posteriorly and are opposed oesophageal pouches.

Intestine origin (caeca, typhlosole): In 15 the intestine widens appreciably; simple, laterally paired tapering caeca 25-24, one arm bent under septum 25/26 (septa of segment 26 converge); typhlosole not found to about 30.

Nephridia: Meroic (what appeared to be nephridia on the duct of one anterior spermatheca where not found on any other ducts – RJB pers. obs.).

Male organs: Testes/funnels metandric: paired testis sacs in 11 incorporated with a large pair of seminal vesicles, reaching to the dorsum in 11 also in 12.

Ovaries: Paired in 13 as clusters of egg-strings from the anterior septum, ventrally.

Prostates: Paired,blocky racemose glands with short ducts in 18 extend from 16,17-21.

Spermathecae: Elongate ampullae demarcated off tapering ducts each with a small clavate diverticulum. Note: the latter two pairs of spermathecae were contained between 7/8 and 8/9, i.e., in segment 8.

Gut contents: Fine soil material bound in mucus.

Notes: Septum 8/9, as noted, is weak and adpressed on 9/10 and the spermathecae of 8 and 9 are combined in 8, perhaps this condition represents incipient septum deletion. Moreover, the oesophageal swellings may be interpreted as 'oesophageal pouches'" as found in some pheretimoid genera.

Remarks: Fletcher's account has the gizzard in 7-8 with the intervening septum deleted, which is possibly a miscount, although he gives the intestinal origin in 15 and the caeca in 25-21 as here. Lee (1981: 546,557) compares ten octothecal species, most complying with a metandric *Amynthas versteegi* group of Sims & Easton (1972), found in the New Guinea, Indonesia and Pacific regions, including *B. queenslandicus* and octothecal morphs of parthenogenetic *Metapheretima speiseri* (Michaelsen, 1913) complex.

Genus ***Duplodicodrilus*** Blakemore, 2008

Duplodicodrilus Blakemore, 2008.

Type-species: *Megascolex schmardae* Horst, 1883: 194 from "*Japan*". [Non *Megascolex schmardae* Michaelsen, 1897: 208 from "*foot of Adams Peak*", Sri Lanka for which replacement is not automatically required and prevailing usage is maintained (under ICZN, 1999: Art. 23.9.5) since these taxa have not been considered congeneric >1899, e.g. Michaelsen (1900) held them in separate genera].

Diagnosis: Male pores within copulatory pouches on segment 18, eversible as large inflatable and doubled intromittant organs or pseudo-penes (Fig. 6). Genital markings lacking. Intestinal caeca typically manicate or complex, paired in segment 27 (Fig. 7) or simple and occasionally incised. Holandric. Spermathecal pores paired in 7/8/9.

Included species: *Duplodicodrilus schmardae schmardae* (Horst, 1883) (type); *Perichaeta trityphla* Beddard, 1896: 205 from Barbados, types BMNH:1904.10.5.169 (actually 1904:10:5:69 – pers. obs. RJB 19.VI.2013); *D. acinctus* (Goto & Hatai, 1899) as redescribed by Blakemore (2012) on NMST neotype [including its synonym *M. yezoensis* (Ohfuchi, 1938)]; and *Pheretima kikuchii* Hatai & Ohfuchi, 1936: 767 from Japan. *D. schmardae macrochaeta* (Michaelsen, 1899: 235 is listed as a subspecies by Sims & Easton (1972: 239) which, as described by Michaelsen (1900: 302), is from Japan and "*Tiensin, China*" but it is not certain that its reported fewer setal variations are outside of normal intraspecific variability.

Etymology: For the doubled, eversible copulatory organs resembling 'air-bags' in this worm (gender masculine).

Distribution: Oriental (Japan, China), the nominal type widespread by transportation.

Remarks: Male organs of *Duplodicodrilus schmardae* differentiate it from other comparable pheretimoid genera: male pores are superficial in *Amynthas* Kinberg, 1867: 97 (Fig. 1) or non-superficial in *Pheretima* Kinberg, 1867: 102 (Fig. 2) and *Metaphire* Sims & Easton, 1972 (Figs. 3-5). The newly proposed genus is most derived in its complex eversible male organs (Fig. 6), combined with its complex intestinal caeca (Fig. 7) that is perhaps less taxonomically important. The elaborate eversible male organs of *Duplodicodrilus*, used for mutual charging of spermathecae, differ from those found in *Metaphire* and, moreover, lack of spermathecal nephridia differentiate both from *Pheretima s. stricto*.

Several other taxa described with large and eversible male pores, possibly also forming doubled intromittent organs or pseudo-penes, that may qualify them for

inclusion with *D. schmardae* in *Duplodicodrilus*. Likely candidates species are:

- *Metaphire bipora* (Beddard, 1900: 908) plus its synonyms from "Malay Peninsula" (including Singapore), Myanmar, and Thailand that has one or two pairs of genital markings (in 19 or 19 and 20) themselves resembling copulatory pouches, four pairs of spermathecae in 5/6/7/8/9 and simple intestinal caeca;
- and *M. virgo* (Beddard, 1900: 895) from Thailand, Malaysia and Myanmar with spermathecae in 6/7/8/9 that also has simple intestinal caeca.

Inclusion of these taxa would require expanding the generic definition to include their characteristics (e.g. simple caeca, extra spermathecal pores and genital markings) as well as genus distribution.

Less likely candidates described with large eversible intromittent organs are:

- *M. kengtungensis* (Gates, 1931) from Myanmar and Laos with spermathecae in 7/8/9 that has glands within its copulatory pouches "*perhaps somewhat as in P. schmardae*";
- *M. quadrigemina* (Gates, 1932) from Myanmar with spermathecae in 6/7/8/9;
- *M. brevipenis* (Qiu & Wen, 1988) from Guizhou, China with spermathecal pores in 7/8/9 and simple caeca;

Another possible member of this group is Gates' (1972: 199) rather contradictory concept of *Metaphire malayana* (Beddard, 1900) [cf. *M. bipora* and *Pheretima (Pheretima) darnleiensis* as redescribed by Blakemore (2002; 2006; 2007)].

Determination of membership in *Duplodicodrilus* requires inspection of all the taxa listed above (plus their synonyms) probably including DNA 'fingerprinting' or 'barcoding', preferably of (neo)types, and their comparison with the type, but this work is mostly beyond the resources of the current study and is deferred.

Duplodicodrilus schmardae schmardae (Horst, 1883)

Fig 2.17a *Duplodicodrilus schmardae*, eversible male pores and intromittent organs (after Hatai & Ohfuchi, 1936, figs. 4, and 8 for their *P. kikuchii* synonym).
Fig 2.17b *D. schmardae*, manicate (or multiple) intestinal caeca (after Hatai & Ohfuchi, 1936, fig. 9 for their *P. kikuchii* synonym).
Fig 2.17c Possibly synonym, *Metaphire vesiculata* (Goto & Hatai, 1899: 21, figs. 13-15).

Megascolex schmardae Horst, 1883: 194. [From "Japan". Syntypes in Leiden: 1818 (inspected by Sims & Easton, 1972: 181 and 191 where the multiple = manicate condition of caeca was noted since Horst omitted its mention); types also

(erroneously?) reported as in Vienna: 3970 by Reynolds & Cook (1976)]. [Non *Megascolex schmardae* Michaelsen, 1897: 208 from "*foot of Adams Peak*", Sri Lanka. Since these taxa have not been considered congeneric after 1899, e.g. Michaelsen (1900) had them in separate genera, a replacement name is not automatically required and prevailing usage is maintained (ICZN, 1999: Art. 23.9.5)].

?[*Perichaeta sumatrana*: Beddard, 1892a:155, Pl IX, fig. 4, (?non *Megascolex sumatranus* Horst, 1883: 189) – cf. *Metaphire californica* and *M. javanica*].

Perichaeta trityphla Beddard, 1896: 205, . [From Barbados. Types BMNH:1904.10.5.169 (actually 1904:10:5:69 – pers. obs. RJB 19.VI.2013)]. [Name misspelt "trityphia" e.g. Sims & Easton (1972: 246), or "triphyla"].

?*Perichaeta vesiculata* Goto & Hatai, 1899: 21, figs. 13-15. [From Takahashi (Bitchu = Okayama-ken) and Oarai (Ibaraki-ken, Honshu). Types not known. Described with spermathecal pores in 6/7/8 – but maybe a mistake (as for *P. parvicystis*)?!].

Amyntas schmardae [sic]: Michaelsen, 1899: 13; Beddard 1900a: 619 (syn. *trityphla, vesiculata*); Beddard, 1900b: 426 (syn. *trityphla, vesiculata* Goto & Hatai).

Pheretima schmardae: Michaelsen, 1900: 302 (syn. *trityphla*); Chen, 1930?: 12, fig. 15; Gates, 1937: 368 (syn. *trityphla, capensis, sumatrana* – after inspection of a type of *trityphla*); Gates, 1939: 482 (omitting *trityphla* nevertheless gives syns. *sumatrana, macrochaeta* (part?), *capensis* (part), *quadragenaria* – this latter synonym is unlikely as the species has exceptionally long and coiled stalks to the spermathecal diverticula - see Perrier, 1872: fig. 69 and cf. *P. inflata* Horst, 1893: fig. 8; indeed, on reinspection of Gates' originals we can fathom that he is only referring to other authors' versions of these taxa and thus we must re-check and re-read all these accounts; he did however on page 483 discern complex manicate caeca as confirmed by Sims & Easton's (1972: 181, 191) inspection of the *schmardae* type; Kobayashi (1941b: 259 (syn. *vesiculata*); Gates, 1982: 65; Kuo, 1995: 188 (misidentification from Taiwan?).

Pheretima kikuchii Hatai & Ohfuchi, 1936: 767. [Types?].

Metaphire schmardae schmardae: Sims & Easton, 1972: 239 (*schmardae*-group); Blakemore, 2003.

Metaphire schmardae : Easton, 1981: 58 (syn. *kikuchii*); Sims & Gerard, 1985: 132, fig. 47e (syn. *sumatrana*: Beddard, non Horst, 1883). [Note: as Beddard's (1892) account of *sumatrana* from Kew Gardens did not mention that the intestinal

caeca were manicate, therefore it is more likely that these specimens were of *Metaphire californica* or possibly *M. javanica* - especially since Sims & Easton (1972: 239) placed it in the *javanica*-group with simple intestinal caeca. Loan requests for specimens of Beddard's *sumatrana* from BMNH were unsuccessful as they could not be found there].

Duplodicodrilus schmardae schmardae; Blakemore, 2008: 22; 2010.

Note: As remarked on above, Sri Lankan *Megascolex schmardae* Michaelsen, 1897 is different to *Megascolex schmardae* Horst, 1883 (= *Duplodicodrilus schmardae*).

Dignosis: Spermathecal pores paired, c. 0.5 circumference apart in furrows 7/8/9. Male pores (at centres) on huge eversible stuctures within copulatory pouches on segment 18. Genital markings lacking. Intestinal caeca manicate in segment 27.

Distribution: Japan (type locality); Hawaii (e.g Oahu); Antilles; Bermuda, Bahamas and Barbados; Sao Paulo, Brazil (eg. Righi, 1980 plus other recent Brazilian reports that, however, are unconfirmed against *M. californica* by touristic, non-specialists who are renowned for confusing Families and Genera thus little confidence can be placed on their species determinations either); China (e.g. "Tientsin", Hongkong, Macao, Szechuan, Chekiang and Hupei); Taiwan; and Kew Gardens [the report from Kew Gardens was thought a probable misidentification by Beddard of *M. californica* according to Gates, but Beddard (1900: 426) clearly states *D. schmardae* has manicate caeca]; Madagascar (e.g., Cognetti, 1909), Reunion and Philippines by interception (Gates, 1982: 65). It is not known how many of these records are mis-identifications of other species such as *M. californica*, but this author suspects several (e.g. from Brazil where only "*Metaphire schmardae*" is claimed to occur, i.e. no *Duplodicodrilus* and no *M. californica* – this highly unlikely, as well as the other option being in the wrong genus!).

Taxonomic Note: Unless the male pores are shown to be deeply invaginated and eversible as duplicated male organs (plus caeca shown to be manicate), then most extraneous records for *D. schmardae* are more likely to be of *Metaphire californica*. *M. vesiculata* (Goto & Hatai, 1899) from Japan is similar but differs, not least, in its spermathecae in 6/7/8, althought this may be a mistake by those consistently unreliable authors (cf. *M. javanica / M. californica* and the *M. kikuchii* synonym).

Locality: This description is extacted from the references give in the synonymy and from this author's Japanese studies.

Habitat: ?

Behaviour: Male pores evert like twin 'air-bags' for copulation.

Length: 52-90.

Width: 2-4 mm.

Segments: 90-93.

Colour: Golden grey.

Prostomium: Epilobous.

First dorsal pore: 12/13.

Setae: numerous (ca. 50-60).

Nephropores: ?

Clitellum: Annular 14-16.

Male pores: Ca. 0.3 circumference apart in lateral slits of copulatory pouches on 18.

Female pore: On 14.

Spermathecal pores: Two pairs in 7/8/9 ca. 0.5 circumference apart.

Genital markings: None.

Septa: 6/7-7/8 thick, 8/9-9/10 aborted.

Dorsal blood vessel: Single.

Hearts: Last pair in 13.

Gizzard: In 8.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): In 15; caeca manicate in 27-24; typhlosole present.

Nephridia: Meroic.

Male organs: Testes/funnels in 10 and 11 in sacs; seminal vesicles large in 11 and 12.

Ovaries: In 13.

Prostates: Racemose with S-shaped ducts.

Spermathecae: 8 and 9 with short duct and ampulla and long bent diverticulum.

Gut contents: ?

Remarks: The distinctive manicate caeca have three or more 'fingers'.

Other species with large and eversible male pores, possibly also with intromittent organs or pseudo-penes, are *M. bipora* (Beddard, 1900), *M. virgo* (Beddard, 1900), *M. kengtungensis* (Gates, 1931), and doubtfully *M. quelparta* (Kobayashi, 1937) plus its possible synonym *M. sanseiana* (Ohfuchi, 1951), *M. quadrigemina* (Gates, 1932), and *M. brevipenis* (Qiu & Wen, 1988). Another possible member of this grouping would be Gates' (1972: 199) rather unreliable concept of *Metaphire malayana* (Beddard, 1900) [cf. *M. bipora* and *Pheretima (Pheretima) darnleiensis*].

Sims & Easton (1972: 239) list the subspecies ***Metaphire schmardae macrochaeta*** (Michaelsen, 1899) which, as described by Michaelsen (1900: 302), is from Japan and "*Tiensin, China*", thus qualifying as peregrine in one or other place (or both places?), and it was differentiated on details of its anterior setae. It is briefly described below…

Duplodicodrilus schmardae macrochaeta (Michaelsen, 1899)

Perichaeta schmardae : Michaelsen, 1892: 235.

Perichaeta schmardae var. *macrochaeta* Michaelsen, 1899: 227. ["Japan" and Tsiensin, China. Types in Hamburg?].

Pheretima schmardae var. *macrochaeta* : Michaelsen, 1900: 302.

Pheretima schmardae (part. or whole?) : Gates (1939: 482) [inspection of 11 soft mature specimens from Hamburg Museum labeled "*Pheretima* (*Ph.*) *schmardae* Horst var. *Macrochaeta* (Mich.). China. Hongkong, Kowloon, Kraff l.d.", i.e., not types!; plus other material from China that he place under (a composite description of) *Ph. schmardae* even though he described most of these specimens with less than 50 setae in the anterior segments].

Metaphire schmardae macrochaeta: Sims & Easton, 1972: 239; ?Easton, 1981: 58 (by reference to Michaelsen, 1892: 235).

Duplodicodrilus schmardae macrochaeta : Blakemore, 2008: 26.

Diagnosis: As *D. schmardae schmardae* but with 50 or less setae in the anterior and those on segments 4-6 enlarged and ornamented.

Distribution: Japan and China (Tiensin) by Michaelsen (1900: 302).

Remarks: It is not certain that these stated variations are outside of normal intraspecific variability and its merger with the nominal subspecies is mooted.

Genus ***Metapheretima*** Michaelsen, 1928

Metapheretima Michaelsen, 1928: 8; Sims & Easton, 1972.

Type-species: *Perichaeta neoguinensis* Michaelsen, 1892.

Diagnosis: Megascolecidae with an oesophageal gizzard in 8, lacking intestinal caeca and gizzards; oesophageal thickenings or pouches present or absent. Setae perichaetine. Prostates racemose. Crescent genital markings usually [but not always, e.g. *Me. andurili* , *Me. deirdrae* both by Easton, 1979, and *Me. parmata* (Ude)] associated with the male pores on 18 (as with the caecate genus *Begemius*); copulatory pouches with penial bodies may be present, but superficial porophores are typically absent (cf. *Archipheretima*, *Polypheretima*).

Distribution: New Guinea, New Britain, Lombok, possibly indigenous (?neoendemic) to Carolines, Solomon Island and Vanuatu; about 37 species.

Habitats: either soil-inhabiting, under piles of decayed coconut husks, or in rotting logs and leaf bases; mountainous and sometimes arboricolous.

Remarks: Acaecate species without crescentic markings around the male pores, that tend to be on porophores or in small copulatory pouches that however lack the penial bodies of *Metapheretima*, go into *Polypheretima*. Species with crescentic marks and caeca near 25 go into *Begemius*. Originally separated from *Metapheretima* by its oesophageal pouches, *Ephemitra* Sims & Easton, 1972 was merged by Easton (1979).

Key to peregrine species of *Metapheretima* in Pacific Ocean

1. Spermathecal pores multiple, dorsal in 5/6/7/8 ……..…. *M. carolinensis*
   Spermathecal pores paired, ventral …… 2
2. First spermathecal pores in 4/5 (five thecal segments) 3
   First pores in 5/6 or 6/7 (three or four thecal segments) ..... *M. speiseri* (part).
3. Spermathecal and male pores c. 0.5C apart, crescentic markings only anterior to male pores not on either side; diverticula simple ..... *M. pickfordi*
   Spermathecal pores <0.5C apart; diverticula not always simple 4
4. Spermathecal pores 0.26-0.40C apart in (4/5/)6/7/8/9; simple diverticula; male pores 0.22C apart or absent ..... *M. speiseri* (part).
   Spermathecal pores 0.2-0.28C apart; sometimes with bifid (or multiloculate?) diverticula; male pores 0.1-0.2C apart ..... *M. loriae*

Metapheretima carolinensis (Michaelsen, 1910)

Fig. 2.2.1.1 *M. carolinensis* after Easton, (1979, fig. 39b); sp - dorsal spermathecal pores.

Pheretima carolinensis Michaelsen, 1910: 105, fig. XXI. [Types Hamburg 3301]; Ohfuchi, 1940: 7.

Pheretima (*Polypheretima*) *carolinensis*: Michaelsen, 1934: 15.

Pheretima garama Gates, 1958a: 8-11. [From Tokongo Islet, Caroline Ils. AMNH: 3569].

Metapheretima loriae: Sims & Easton, 1972: 233; Easton, 1979: 96, figs. 39b.

Diagnosis: *Metapheretima* numerous, dorsally placed spermathecal pores in furrows 5/6/7/8. GM absent apart from crescents around simple male pores on 18.

Distribution: Caroline Islands, as an introduced species or neoendemic, and Sumatra (North Lampung);

Notes: Gates' specimens were found under coconut husks and he considered them to have parthenogenetic characteristics and to be subject to posterior regeneration.

Metapheretima loriae (Rosa, 1898)

Fig. 2.2.1.2 *M. loriae* after Easton, (1979, fig. 33, 40 – with no ©).

Perichaeta loriae Rosa, 1898: 61. [Type locality "Hughibagu" - Rosa, although locality may be Hughes Bay, Furgusson Islands. Type in Genoa, 44020 or 37]; ?Beddard, 1899: 185 (?= *M. pickfordi* according to Easton, 1979: 99, cf. Lee, 1981).

Amyntas loriae: Beddard, 1900a: 641.

Pheretima loriae: Michaelsen, 1900: 281.

Metapheretima loriae: Sims & Easton, 1972: 231; Easton, 1979: 99, figs. 33a, 40a; Lee, 1981: 554, figs. 16-17 (spermathecae, but not of the type).

Diagnosis: *Metapheretima* with 5 pairs of spermathecal pores 0.2-0.28C apart in 4/5/6/7/8/9 with clavate (e.g. Lee, 1981, fig. 16), or sometimes with bifid (or multiloculate?) diverticula (e.g., Easton, 1979:, fig. 33a; Lee, 1981: fig. 17). Male pore simple 0.1-0.2C apart. Female pores paired. GM paired 8 and 9 and 17,(18),19(-20). Intestinal caeca absent. Hearts 10-13 (Easton) or 10-12 (Lee). Metandric. Length c. 110-130 mm. Puce or grey dorsum. Setae 50-80 per segment.

Distribution: Papua New Guinea ("*Hughibagu*" - Rosa, although the locality may be Hughes Bay, Furgusson Islands according to Easton, 1979: 100), Guadalcanal, Solomons (Beddard, 1899 - questioned by Easton, 1979: 100 cf. Lee, 1981: tab. 1), and Aneityum Is., VanuaTu (Lee, 1981: 554). From rotten logs, and epiphytes (Lee).

Notes: *M. sucklingensis* Easton, 1979: 102, fig. 41a from PNG (multilocuate spermathecae exiting in 6/7/8/9) is close morphologically.

Metapheretima pickfordi (Gates, 1959)

Fig. 2.2.1.3 *M. pickfordi* after Easton, (1979, fig. 36– with no ©).

Pheretima pickfordi Gates, 1959: 18. [Type locality Lavanggu, Rennell Is., Solomons. Type lost]; Lee, 1969: 347; 1969a: 4. [Note: Sims & Easton (1972), Reynolds & Cook (1976: 155) and Easton (1979; 1984) date as "Gates, 1957"; Lee (1981) and Blakemore (1997: 25) have it, as here,"Gates, 1959"].

Metapheretima pickfordi: Sims & Easton, 1972: 231; Easton, 1979: 91, fig. 36b; Lee, 1981: 554, figs. 18-19.

Diagnosis: *Metapheretima* with 5 pairs of spermathecal pores c. 0.5C apart in 4/5/6/7/8/9; simple diverticula. Male pores lateral. Female pores paired. GMs just a pair in front of male pores (Lee) or also with single midventral in 7-9, paired in 17, 19-22,23 (Gates, Easton). Septum 8/9 retained (Easton) or deleted (Lee). Intestinal caeca absent. Last hearts 12. Metandric. Length c. 26-28 (Easton) or 57-81 mm (Lee). Lightly or un-pigmented. Setae 40 or 50-90 or per segment.

Distribution: From coconut grove Lavanggu, Rennell Is (Gates) and Guadalcanal, Solomons (Lee, 1969); and from soil in vine forests on Espiritu Santo, Malekula and Efate Isls., VanuaTu (Lee, 1981).

Notes: Easton (1979: 92, 99) questioned whether Beddard's (1899: 185) record of *P. loriae* from the Solomons was in actuality *M. pickfordi*; Lee (1981: 538, tab. 1) makes no comment but lists both *M. loriae* and *M. pickfordi* from Solomons. Because the unique holotype was damaged, neither Gates nor Easton (1979) were sure whether *M. pickfordi* was holandric or metandric, but Lee (1981: 556) found the latter condition for his new material. Lee (1981: 553) compares *Me. pickfordi* that is soil-dwelling with his *Me. erromangae* from Vanuatu that lives above ground.

Metapheretima speiseri (Michaelsen, 1913)

Fig. 2.2.1.4 *M. speiseri* after Easton, (1979, fig. 32, 36– with no ©).

Pheretima speiseri Michaelsen, 1913: 263. [Type locality Espiritu Santo, Vanuatu. Syntypes Hamburg v8071].

Pheretima (*Pheretima*) *speiseri* : Pickford, 1929: 493.

Planapheretima speiseri : Sims & Easton, 1972: 210, 233.

Metapheretima speiseri: Easton, 1979: 92, figs. 32h, 36c; Lee, 1981: 556, figs. 20-24; Easton, 1984: 117.

Diagnosis: *Metapheretima* with 3, 4 or 5 pairs of spermathecal pores 0.26-0.40C apart in (4/5/)6/7/8/9; simple diverticula. Male pore simple, 0.22C apart with two pairs of cresectric markings (that Lee describes as "minute round markings"), or pores and markings absent. GM absent or paired median or wide in 7,8-9, and in line with male pores in 17, 19-20. Septum 8/9 membranous or deleted. Intestinal caeca absent. Hearts 10-12 (Easton) or 10-13 (Lee). Holandric (Easton, 1979: 92) or metandric (Lee, 1981: 557), i.e., probably variable due to polymorphism. Length c. 26-81 mm. Puce colouration dorsally. Setae 28-56 per segment.

Distribution: From summit of mountains to lakeside on VanuaTu (formerly known as New Hebrides) - Banks and Aoba Isls. (Michaelsen, 1913) and Espiritu Santo, Gaua (Banks), and west Santo (Pickford, 1929 according to Easton, 1979: 93) and several other islands by Lee (1981: 538, tab. 1); also as an introduced species to Tonga (Easton, 1984: 117) found under 'salata' and plantation trees, rain forest and fern tree. Lee (1981) found specimens in rotten logs and epiphytes.

Notes: Parthenogenetic polymorphism common, male pores and prostates often deleted and some spermathecae may also be lost; female pores may be single or paired. Thus Gates' parthenogenetic code forms R I and H are reported. *M. speiseri* (Michaelsen, 1913) is possibly a variant synonym of *M. loriae* (Rosa, 1898). Lee's *Me. apunae* from Vanuatu is also similar but Lee (1981: 551) separates them on the basis mainly of more seata (70-90) than *Me. speiseri* (28-56), details of GMs, and soil habitat of *Me. apunae* against the above ground and arboricolous habitats of *Me. speiseri.*

Genus ***Metaphire*** Sims & Easton, 1972

Metaphire Sims & Easton, 1972: 215 (nom. nov. pro *Rhodopis* Kinberg) (Ref).

[Syn. *Rhodopis* Kinberg, 1867: 102; preocc. Reichenbach, 1854 (Aves); et *Rhodope* (lapsus) non Angelin, 1854].

Type-species: *Rhodopis javanica*, Kinberg, 1867 from Java. [non *Woodwardia javanica* Michaelsen, 1910 (= *Lennscolex*)] possible synonym of *M. californica* (pers. obs.).

Diagnosis: Megascolecidae with oesophageal gizzard between 7/8 and 9/10, intestinal caeca from or near 27; intestinal gizzards absent. Setae perichaetine. Male pores within copulatory pouches on 18, or rarely 19 or 20; secretory diverticula not discharging into copulatory pouches (cf. *Manus koellikeri*) but stalked glands often present. Spermathecae paired, rarely multiple or single. Nephridia absent from spermathecal ducts (cf. *Pheretima* and some *Amynthas*).

Note: Specimens lacking male pores 'default' to the prior genus *Amynthas*, those having only one non-superficial male pore comply with non-superficial genera. Athecal morphs (lacking spermathecae) with non-superficial male pores are unusual but would 'default' to *Pheretima* lest thecate morphs were located that lacked nephridia on the ducts. Obviously *Metaphire* is a taxonomic genus of "convenience" but its merging with *Amynthas* requires demonstration that the types of both genera are equivalent and this is unlikely; possibly other genera names are available from various *Pheretima* synonyms.

Metaphire differs from *Amynthas* mainly on its copulatory pouches (CPs, i.e. inverted penes) often accompanied by a reduction or loss of genital markings (suckers and/or locators) required with the superfgicial male pores of *Amynthas* taxa to facilitate the efficient transfer of semen between con-copulants. *Metaphire* CPs are a development.

Taxonomic Notes: In my opinion, *Metaphire javanica* (Kinberg, 1867: 102) is similar to *M. californica* (Kinberg, 1867: 102) and if they eventually prove to be synonymous, the latter name has priority on the page and may replace *javanica*.

Remarks: Gates (1982: 38), himself a constant denier of taxonomic progress in pheretimoids (e.g. he deliberately ignored Sims & Easton's 1972 revisions for a decade!), commenting about male terminalia invaginations has led some equally ignorant contemporaries to doubt *Metaphire* Sims & Easton, 1972 (e.g. see James, 2005b; James *et al.* 2005 as cited by Chang *et al*., 2009: 4; or the various papers by James & Hong and Hong & James, etc.). What he (and they) fail to grasp is that regardless of petty politics,

under the rules and recommendations of ICZN that all good taxonomists are obliged to follow, it is the condition pertaining in the type-specimen of the type-species of the genus that defines the genus. Hence *Metaphire* is for species similar to its type having (as defined by Blakemore, 2000 and subsequently) "*non-superficial*" male pores, **regardless of depth of invagination**! For emphasis of such error, Chang *et al*. (2009: 4) state that James cited Gates' words and commented (James *et al.*, 2005):

"*Gates (1975, p 7) wrote, "Presence or absence of copulatory chambers is too vague. The really important character is whether the male pores are superficial or invaginate. In the latter case, whether in slight transverse slits or much deeper spaces still confined to the parietes or whether thick-walled copulatory chambers deeply penetrating into coelomic cavity (cf Gates 1972, p. 150)"... ... We support following the suggestion of Gates (1975) to better characterize the status of various types of non-superficial male pores. For now we support restricting* Metaphire *to those species distinguishable from* Pheretima *only by the absence of nephidia from the spermathecal ducts (Sims and Easton 1972). This would require the presence of well-developed copulatory pouches protruding into the coelom (as in* Pheretima*), but leaves unclear what to do with species whose copulatory pouches are entirely intramural and could thus be distinguished from* Pheretima."

Probably requiring specialist help, James *et al.* (2005) then went on to attempt to describe eight "*new*" species that were soon found junior synonyms of well-known taxa.

Distributions: Oriental region from Japan southwards and throughout Oceania. Approximately 180 nominal species, a dozen of which are peregrines with two or three reported for Australia (Easton, 1982; Blakemore, 1999).

The first ever described Japanese native, *Metaphire sieboldi* (Horst, 1883) see Blakemore (2003, 2013, 2020) is recorded (as "*2009.120-122 - Amynthas siebaldi*") from Indonesia, but this is probably a misidentification. Representative taxon of the *A. sieboldi*-group of Sims & Easton (1972) is replaced after transfer of *sieboldi* to *Metaphire*.

Keys to cosmopolitan pheretimoids are found above.

Metaphire anomala (Michaelsen, 1907)

Pheretima anomala Michaelsen, 1907b: 167, fig. 14. [Type locality Botanic Gardens

near Calcutta. Types in Indian and Hamburg Museums].

Pheretima anamola (sic lapsus): Stephenson, 1923: 294.

Pheretima insolita Gates, 1925: 543. [Type locality Rangoon. Types in US Natl. Museum]. [There is some conflict in this name as Sims & Easton, 1972: 237, 243 misspell the name "*insolata*", and Reynolds & Cook, 1976: 118 (mistakenly?) ascribe it to both Gates (1925: 568) and to Stephenson (1929: 234) but this is corrected in Reynolds & Cook (1981: 32)].

Pheretima anomala centralis Stephenson, 1929: 234. [Types lost].

Pheretima anomola: Gates, 1954: 1; 1972: 166 (syn. *insolita*, *centralis*).

Metaphire anomola anomola: Sims & Easton, 1972:237 (sic lapsus pro *anomala*).

Metaphire anomala : Blakemore, 2002, 2006, 2008, 2010 (syns. as above).

Diagnosis: *Metaphire* with three pairs of spermathecal pores in 5/6/7/8 (sometimes lacking). Male pores paired in copulatory pouches on 20. Genital markings small, paired 17-19. Intestinal caeca simple originating in 27. Parthenogenetic variations common.

Distribution: India (by introduction), Myanmar, Thailand, Vietnam, and China (Yunnan).

Behaviour: ?

Length: 80-200.

Width: 3-7 mm.

Segments: 119-130.

Colour: Reddish.

Prostomium: Epilobous.

First dorsal pore: 12/13.

Setae: Numerous, ca. 60-100 per segment.

Nephropores: Not found.

Clitellum: Annular in 14-16.

Male pores: In copulatory pouches on 20.

Female pores: Single on 14.

Spermathecal pores: Three pairs in 5/6/7/8,invaginated, sometimes lacking or irregular.

Genital markings: Small, paired discs in 17-19.

Septa: 8/9-9/10 aborted, none very thick.

Dorsal blood vessel: Single.

Hearts: 10-13.

Gizzard: Between septa 7/8 and 9/10.

Calciferous glands: Oesophagus pouches absent.

Intestine origin (caeca, typhlosole): In 15; simple, laterally paired caeca simple in 27-21; typhlosole present.

Nephridia: Meroic, (?tubules absent from spermathecal ducts).

Male organs: Testes/funnels in sacs in 10 and 11; large seminal vesicles in 11 and 12.

Ovaries: Paired in 13.

Prostates: Large, racemose extending from 16-23, ducts muscular and looped to copulatory pouchs on 20.

Spermathecae: In 6-8, slender diverticulum with short slender stalk and wider looped middle portion to club-like seminal chamber.

Gut contents: ?

Remarks: Facilitative or obligatory parthenogenesis is suspected for this species as Gates (1972: 167) described an almost complete series of degraded morphs (H, A, R, etc.). It is doubtfully related to *Metaphire megascolidoides* (Goto & Hatai, 1899) from Korea and Japan that has male pores on segment 19, although its spermathecae are in 4/5/6/7/8/9, genital markings are small paired postetal in line with the male pores on 17, 18 and 20, and the intestinal caeca are manicate and deeply incised (erroneously stated to be simple by Easton, 1981). Other species with male pores in 19 are *Metaphire isselii* (Cognetti, 1908) and *Amynthas cruratus* (Chen, 1946).

Metaphire bahli (Gates, 1945)

Fig. 2.3.1. Specimen from Darwin, NT.

Pheretima bahli Gates, 1945: 85. [Type locality Colombo, Sri Lanka. Types, supplied by Kirtisinghe, originally in Prof. Bahl's collection, now lost]; Gates, 1972: 209; Thai, 2000 (part. with syns. *saigonensis*, *bangoiana*).

Pheretima peguana: Kirtisinghe, 1939: 89 (*Spolia Zeylandica*: 21: Gut histology).

Pheretima peguana: Dissanaike, 1953: 161 (*Ceylon J. Sci.* 25: Protozoan parasites).

Pheretima bahli: Refuerzo & Reyes, 1959: 56-58 (*Philippine J. Animal Industry*, 19: Larval parasites of *Metastrongylus apri*).

?Pheretima sp. Gates, 1972: 210. [Believed to be from Thailand].

Metaphire bahli: Sims & Easton, 1972: 239; Easton, 1982: 730, fig. 4f; Blakemore, 2002; 2016.

Diagnosis: *Metaphire* with paired spermathecal pores just less than 0.5 body circumference apart in 6/7/8/9. Diverticula coiled with terminal bulb. Paired intersegmental genital markings as invaginate elliptical pads with central apertures, in line with the male pores, in 17/18 and 18/19 (cf. *M. peguana*). Intestinal caeca simple.

Note: In a Vietnamese paper by Thai (2000; repeated in PhD thesis by T.T. Nguyen, 2013: 46) it was suggested that *Pheretima bahli* had synonyms of *Pheretima saigonensis* Omodeo, 1956 and *Amynthas bangoiana* (Michaelsen, 1934: 505 figs 6-8 with type in Paris, 576 as briefly summarized below). This seems unlikely as the male pores and GMs differ, but if it were so, then the latter species would take priority from Gates' *bahli*. Information to hand suggests Omodeo's *P. saigonensis* previously held in synonymy of *Metaphire peguana* (see its description below) should be restored.

Thai & Samphon (1989: 64, 75) argued that their *Metaphire pacseana* (Thai & Samphon, 1988) from Vietnam/Laos explains the relationship between *M. bahli* and *M. peguana*; it has similar markings 17/18 & 18/19 but is larger, up to 270 mm long, with diverticulum twice the length of the ampulla plus duct (no nephridia), and a deeply incised and multiple intestinal caeca. It was tentatively placed in *Metaphire* by Blakemore (2008); in a photograph in recent paper by Nguyen (2014: fig. 1B) it seems not to have nephridia on the spermathecal ducts supporting this move.

Material: UPV sample #S14 coll. RJB 14th Aug. 2013 Kahariam farm, Lipa City, Batangas, under stone beside farm office, clitellate mature, 135 mm long, dissected and providing DNA sample K2; #S16 same location, in vermicompost beds mature, 95+ mm; #S18 one of three specimens, 105 mm long from rice paddy near gym (DNA P5); #S20 rice paddy beside gate (DNA P7); #P2 coll. 28th Aug. 2014 Penalosa farm, Victorias, Negros, longest of four matures providing DNA (Pe2); #S31 two matures (l = 120 mm) , coll. 30.I.2014 from Hacienda Remedios farm, Negros in banana grove. Other specimens inspected were from Darwin Museum, NT.

Distribution: Recorded from Sri Lanka, the Philippines [previously from Manila and Clark Field (= Angeles City) (Gates and pers. obs.), and Sual, Pangasinan; currently from Batangas and Negros as new records], Laos, Vietnam (Thai & Samphon, 1989; and Ref.), Cambodia (Thai & Do, 1989) and pers. obs. at Ankhor Wat Temple grounds (11 November, 2003), and Thailand (Gates, 1972: 201; Blakemore, 2006). Its records in Australia are from around Darwin, NT (Easton, 1982): from Snake Bay, Melville Island, Elizabeth River 8 Km S of Darwin and beside Manton River 60 Km S of Darwin; in current studies it was found excusively in the central Bicentennial park of Darwin and

through to the Botanic Gardens there many specimens were in the drainage ditches and dried on pavements. Gates (1972) thought many of these records are by introductions and that the original home may be centred in what is now Thailand/Laos.

Gates' *Pheretima* sp. listed in the synonymy above is stated to have a male field still more depressed than in *M. bahli* (cf. *M. peguana*, *M. pacseana* and *M. saigonensis*).

Habitat: Variable; parks, fields, woodlands, paddy and in vermicompost wormbeds (Kahariam farm Batangas). Presence of this worm is associated with rich, much well drilled soil with copious surface casts (pers. obs. in Darwin Gardens).

Behaviour: Usual 'snaking' escape response. Field identification by slight pressure around male pores causes eversion of these plus GMs to give a 6-pointed star formation.

Length: 110-150.

Width: 4-6 mm.

Segments: 92-119.

Colour: Reddish in dorsum.

Prostomium: Open epilobous.

First dorsal pore: 12/13.

Setae: Numerous (ca. 30-68).

Nephropores: Not visible.

Clitellum: Annular 14-16 (white).

Male pores: In lateral slits in copulatory pouches of 18.

Female pore: On 14.

Spermathecal pores: Three pairs in 6/7/8/9 ca. 0.25 (Easton, 1982) or <0.5 (Gates, 1972) circumference apart.

Genital markings: Invaginate in 17/18 and 18/19 on either side of male pores (with muscular genital glands internally).

Septa: 8/9/10/11 aborted, 11/12-12/13 thickened.

Dorsal blood vessel: Single.

Hearts: Hearts of 10 lacking (always?), 11-13.

Gizzard: In 8.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): In 15; caeca simple in 27-22; typhlosole small.

Nephridia: Meroic.

Male organs: Testes/funnels in 10 and 11 in sacs; large seminal vesicles in 9 and 12.

Ovaries: In 13.

Prostates: Racemose in 17-21, ducts long.

Spermathecae: Small in 7-9 with duct shorter than ampulla and diverticulum ectally that has slender looped stalk and terminates in small seminal chamber.

Gut contents: Soil.

Remarks: Gates (1972: 210) remarked that it remains to be demonstrated that *M. bahli* and *M. peguana* are separate taxa, as the former can be distinguished from the latter almost only by the invagination of its genital markings, although he also noted that the two entities have yet to be found in the same locality. It now seems they should be maintained separately due to DNA data but pending designation of a neotype. The description above is taken from Gates (1972) and personal observation of Darwin specimens and, more recently of Asian specimens from Cambodia and Philippines. In the description of *M. peguana* below are citations of DNA COI barcoding studies that should help differentiate taxa from Blakemore (2016).

Amynthas bangoiana (Michaelsen, 1934)

Fig. 3.2.1a from Michaelsen's original figs. 6-8.

Pheretima (*Ph.*) *bangoiana* Michaelsen, 1934: 505 figs VI-VIII. [Type locality "*Süd-Annam, Bangoï (Cam Ranch)*". Types in Paris (576)].

Amynthas bangoiana : Sims & Easton, 1976: 236.

Distribution: Cam Rahn Bay (Port of Ba Ngoi), Vietnam.

Diagnosis: Gold-brown colour. Size 170 by 5-6 mm with 160 segments. Setae 40-120 per segment. Spermathecal pores in 6/7/8/9. GMs in 18 and 19 with male pores that are superficial on small circular phorophores central on GMs in 18. Holandric. Spermathecal diverticula are long but coiled. Intestinal caeca simple in 27.

Remarks: Michaelsen (1934: 508) states that the male pores are simple and that "Kopulationstaschen" are absent, thus this taxon belongs in *Amynthas* rather than *Metaphire* and is clearly quite separate from *M. bahli*.

Metaphire bipora (Beddard, 1900)

Amyntas biporus Beddard, 1900: 908. [Type locality "*Malay Peninsula*" (without further indication). Types in British Museum listed by Reynolds & Cook (1976: 79) as BM: 1904:10:5:15-6 (and in the University Museum, Cambridge), were stated by Stephenson (1932: 213) to be three dried specimens in a jar not labeled "*type*" and Gates (1972: 171) said the dried types were of little value; however, Sims &

Easton (1972: 180) claim to have characterized "*Syntypes*" BM: 1969.2.1/5].

Pheretima bipora: Michaelsen, 1903; Stephenson, 1932: 213; Gates, 1972: 171 (syns. *annandalei*, *gemella*, *balingensis*, *flocellana*).

Pheretima annandalei Stephenson, 1917: 386. [From Sing(g)ora, (Songkhla), Thailand. Type, possibly a posterior amputee, in the Indian Museum].

Pheretima gemella Gates, 1931: 379. [From Ye. Types none].

Pheretima balingensis Gates, 1949: 10. [From Baling. Types in Raffles Museum].

Pheretima flocellana Gates, 1949: 15. [From Baling. Types in Raffles Museum].

Metaphire bipora: Sims & Easton, 1972: 237-238 (*bipora* – species group that also includes all of Gates' synonyms above).

Diagnosis: *Metaphire* with paired spermathecal pores ca. 0.5 body circumference apart in 5/6/7/8/9. GMs variously arranged in region of spermathecae and male pores. Distinctive secondary (pseudo-)copulatory pouches may be present (in 17, 19-20, 21) or are lacking; cf. genital markings found in *M. malayana*, *A. fuscatus* and *A. juliani*.

Distribution: 'Malay Peninsula' (e.g. Kaki Bukit; Baling); Myanmar (e.g. Ye); Thailand e.g. Sing(g)ora (Songkhla), Tale Sap. Its domain is said by Gates (1972: 172) to extend from Myanmar "*into the range of* P. malayana"; how much is self aquired is unknown as it appears relatively widespread in South-east Asia.

Habitats: Geophagous but organic material and sometimes twigs found in gut (Gates).

Behaviour: Probably reproduction is biparental rather than parthenogenetic; penes and pseudocopulatory chambers are eversible.

Length: 32-170.

Width: 2-7 mm.

Segments: 79-105.

Colour: Red to bluish-grey in dorsum.

Prostomium: Open epilobous.

First dorsal pore: 11/12/13.

Setae: Numerous (ca. 24-70).

Nephropores: ?

Clitellum: Annular 14-16.

Male pores: On apices of penes in copulatory pouches of 18; both penes and chambers are eversible according to Gates (1972: 172).

Female pore: On 14.

Spermathecal pores: Four pairs of transverse slits in 5/6/7/8/9 ca. or >0.5

circumference apart.

Genital markings: Marking in some of 7-9; 16-19, as single, paired or median papillae; Other papillae present internally on roof of (pseudo-)copulatory chambers when present in some of 17-21, usually 19 and 20. Composite GM glands correspond internally. Pseudocopulatory chambers absent from specimens referred to *gemella* and *annandalei.*

Septa: 8/9/10 aborted, none thickened.

Dorsal blood vessel: ?

Hearts: Hearts lateral in 9,10, lateroesophageal in 10,11-13.

Gizzard: As usual in 8.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): In 15; caeca simple in 27-22; typhlosole simple.

Nephridia: Meroic.

Male organs: Testes/funnels holandric in 10 and 11 in sacs; seminal vesicles in 11 & 12.

Ovaries: In 13.

Prostates: Racemose in 17-20, ducts long.

Spermathecae: Small in 6-9; diverticulum with slender, sinuous or looped stalk terminating in seminal chamber.

Gut contents: Soil (organic matter, twigs)

Remarks: Gates (1972: 172) said that relationship to the prior *malayana* appears to be close, especially in (southern?) forms that lack the invaginate genital markings.

Metaphire birmanica (Rosa, 1888)

Pheretima birmanica Rosa, 1888: 164. [Type locality Bhamo. Types in Genoa]; Michaelsen, 1900: 255; Stephenson, 1923: 295; Gates, 1972: 172.

Amyntas birmanicus: Beddard, 1900: 637.

Metaphire birmanica: Sims & Easton, 1972: 238 (*birmanica* species-group); Blakemore, 2007; 2008, 2010.

Diagnosis: *Metaphire* with paired spermathecal pores 0.5 C apart in 5/6/7/8. Genital markings absent. Intestinal caeca manicate.

Distribution: Myanmar, China (Yunnan), India (Himalayas) and (as '*Pheretima birmanica*') from the Punjab of Pakistan (Ref.), Vietnam, Thailand and Laos.

Habitat: Soils that are red, dark and richly organic or gravelly; in fields, gardens, paddy

ridges and under grass, bamboo, jungle, mud and manures, i.e. versatile and variable.

Behaviour: Composting species?

Length: 100-160.

Width: 4-7 mm.

Segments: ca. 112.

Colour: Brownish to slate in dorsum.

Prostomium: Open epilobous.

First dorsal pore: 12/13.

Setae: Numerous ("*ca. 70*").

Nephropores: ?

Clitellum: Annular 14-16.

Male pores: In longitudinal groove in small copulatory pouches of 18.

Female pore: Median on 14.

Spermathecal pores: Three pairs in 5/6/7/8 nearly 0.5 circumference apart.

Genital markings: None.

Septa: 8/9/10 aborted, 5/6-6/7 thickened.

Dorsal blood vessel: ?

Hearts: 8,9,10 and 11-13.

Gizzard: In 8.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): In 15; caeca manicae in 27-23; typhlosole simple.

Nephridia: Meroic.

Male organs: Holandric: testes/funnels in 10 and 11 in sacs; large seminal vesicles small in 11 and 12.

Ovaries: In 13.

Prostates: Racemose in 16-20, ducts U-shaped.

Spermathecae: With wide duct and diverticulum from parieties long and zig-zagging.

Gut contents: ?

Remarks: Parthenogenesis anticipated according to Gates, (1972) who also thought that this species was most common on jungle covered hills and was possibly introduced to towns with potted plants. This species also claimed as a vermicomposter in India - Ref..

Metaphire californica (Kinberg, 1867)

Fig. 2.18a *Metaphire californica*, Samford Qld., specimen (a) ventral view, (b) prostate, (c) spermathecae, (d) prostomium, (e) intestinal caeca, (f) posterior.

Fig. 2.18b *Metaphire californica*, author's inked version of sketch of a Brisbane specimen with everted penes July, 1998 [AM W.2682 (mis-)labeled as '*M. javanica*' by E. Easton – the co-author of the genus *Metaphire*].

Fig. 2.18c *Metaphire californica*, author's original sketch of specimen AM W.2682.

Fig. 2.18d *Metaphire californica*, specimen NMST An 430 from Saito-Ho-on Kai collection (ex S. Hatai 1920-30s) from Nagasaki-shi misidentified as "*Ph. schmardae*" (= *Duplodicodrilus schmardae*). Probably many similar confusions are made.

Fig. 2.18e *Metaphire californica*, Korean specimen in NIBR collection (Feb., 2012).

Pheretima californica (part) Kinberg, 1867: 102 [part. excl. *Megascolex indicus* Horst, 1883 (= *A. corticis* - see Easton, 1981: 49)]. [Type locality Sausolita Bay, California. Types from San Fransisco in the Stockholm Museum: 160. Often misdated "1866"].

Perichaeta ringeana Michaelsen, 1890: 10; 1899: 116. [Types lost].

Amyntas ringeanus : Michaelsen, 1899: 120 (syn. *guarini*).

?Perichaeta sluiteri Horst, 1890: 234, figs. 4-5. [From Sunda Island "*Billiton*" between Sumatra and Borneo. Types in Leiden, 1828]. **Syn. nov.** [I can find no evidence for nephridia on spermathecal ducts thus provisionally transfer this taxon from *Pheretima* to *Metaphire*; furthermore, there is nothing substantial to separatate it from *M. californica* or its erstwhile junior synonym, *M. javanica*].

Perichaeta sumatrana : Beddard, 1892a: 155, Pl IX, fig. 4 (just of green body). [Non *Megascolex sumatranus* Horst, 1883: 189 (= *M. javanica*)]. Beddard's specimens from both Barbados and Hong Kong requested but are not locatable. Possibly missing and found in BMNH pers. obs. RJB VI.2013.

Perichaeta hesperidum Beddard, 1892a: 169. [From Kew Gardens (type-locality Barbados). Types BM 1904:10:5:13 – stated to be two specimens by Beddard, 1900: 419].

Perichaeta guarini Rosa, 1894: 13. [Types Turin 155].

?*Perichaeta sandvicensis* Beddard, 1896: 203. [From Hawaii and Hongkong - see separate description below].

Amyntas californicus : Beddard, 1900a: 627 (syn. *guarini*, *ringeana*).

Amyntas hesperidum : Beddard, 1900b: 417 (syn. *sandvicensis*; ?*annulata*).

Pheretima browni Stephenson, 1912: 273 (part excluding sexthecal morphs). [From Tengyueh, Yunnan, China. Types in poor condition in Calcutta (4891) and

London (BMNH: 1925:5:12:30) – see notes on this taxon above].

Pheretima kiangensis Michaelsen, 1931: 21. [Soochow. Types in Hamburg].

Pheretima modesta Michaelsen, 1927: 88. [From Myanmar. Types in Hamburg 10423].

Pheretima molesta Gates, 1932: 420. [From Myanmar. Types lost. Cf. *P. browni*].

Pheretima sakaguchii Ohfuchi, 1938: 53, figs. 1-2. [From Wakayama-ken and Kochi-ken, i.e., widespread in Japan. Types not known].

?Pheretima sonaiensis Ohfuchi, 1956: 154, fig. 8. [Appears to differ only in the presence of septum 8/9 [however Ohfuchi (1956: 158) allows this at least ventrally in his *P. californica* from Okinawa)], and a lack of serrations on intestinal caeca]. [From Sonai, Iriomote, Ryukyu. Types not known].

Pheretima californica: Michaelsen, 1900: 258, 275 (syn. *ringeana*, *guarini, ?hesperidum*); 1903: 95; Stephenson, 1933: 916 (?syn. *hesperidum*), text-fig. 15; Gates, 1937: 312, 348; 1939: 427; [syns. *browni* (part), *modesta, kiangensis, ?hesperidum, sandvicensis*]; Kobayashi, 1941b: 258 (syn. *sakaguchii*); Ohfuchi, 1956: 158, fig. 10; Chen, 1959: 10, fig. 11; Gates, 1959b; 1972: 174 [syn. *browni* (part) Stephenson, 1912 "*excluding sexthecal specimens of the types series*" - this obviously a mistake by Gates as Stephenson's taxon was only quadrithecal (cf. *A. morrisi*), *modesta*, *molesta*, "*oslifornica*" Gates, 1955: 83 (lapsus?)]; 1982: 42 (syn. *ringeana, hesperidum*).

Metaphire californica Sims & Easton, 1972: 238; Easton, 1981: 57 (syn. ?*sakaguchii*, ?*sonaiensis*); Easton, 1982: 731; Sims & Gerard, 1985: 132, fig. 47c (syn. *hesperidum*) [Note: Sims & Gerard (1999: 132) claim Beddard's misidentification of *sumatrana* from Kew is *Metaphire schmardae*, and Beddard was sometimes unreliable (see Stephenson, 1932) but he didn't note manicate caeca nor spermathecal pores so it may equally well be in *M. californica* despite the contrary argument put forward by Gates (1937: 371)].

Taxonomic Note: Chen (1931: 137) included *Perichaeta sandvicensis* Beddard, 1896: 203; *Amynthas loehri* Michaelsen, 1899: 12; and *Pheretima kiangensis* Michaelsen, 1931: 21 (non *P. kiangsuensis* Chen, 1930) in synonymy of *Pheretima hesperidum* (Beddard, 1892), which is now in synonymy of *Metaphire californica*, thus these names may also belong. Gates (1932: 376) sifted through earlier work to derive a description of *P. hesperidum* that is indistinguishable from that of *M. californica*, but he questioned inclusion of several of the other names; Gates (1937: 349) put *hesperidum* in synonymy from its type. Later, Chen (1933: 275) had *P. hesperidum* synonyms (those

not original author's descriptions with a "**:**") as:

P. browni Stephenson, 1912.

P. modesta Michaelsen, 1927.

P. browni Gates, 1931 (again a mistake as there is no such name).

*P. browni***:** Gates, 1932 (= *P. molesta*?).

*P. sandvicensis***:** Beddard, 1900 (i.e., not original description!).

Diagnosis: *Metaphire* with paired spermathecal pores in (6/7),7/8/9 ca. 0.3-0.5 circumference apart; genital markings lacking; intestinal caeca simple but sometimes slightly incised. Spermathecal diverticula often tortuous (i.e., a zigzag shape).

Distribution: Probably indigenous to China (or Japan?), this species has been recorded many times from the around the world: e.g. California (Sausolito Bay), Mexico (e.g. Veracruz), Chile, Madeira, Egypt (Cairo), Lebanon, Myanmar, Vietnam, China, Taiwan, Japan, Okinawa, Marquesas, Hawaii, Easter Island, New York, Costa Rica, Panama, Barbados, Brazil, Peru, Argentina, Greece, Azores (Canary Ils.), South Africa (recorded only from experimental plots at Cedara Agriculture College); Sandy Bay in St. Helena (Gates, 1969); Ascension Island Gates, (1969); possibly from New Guinea (see Sillitoe, 2003 quoted under *Po. corethrurus* description below). Cook Islands and Korea (**new records**). Rarely reported from northern Europe, e.g. from Denmark on Skov-og Naturstyrelsen database on introduced taxa www.skovognatur.dk/natur/invasive_arter/images/introarter.xls Jan., 2007]. In Australia previously reported from Toowoomba (eg. Stephenson, 1933); Brisbane (see also AM W2682 misidentified specimen of "*M. javanica*" below); Mundubbera (Camp Creek) and Canungra, all in Qld (Easton, 1982). Jeju Island, Korea – **new record by RJB.**

Locality: Brookfield, Nerang, Samford, Gayndah, Rockhampton, all new records in Qld, also Toowoomba (RJB) and from Victoria Park, Brisbane, Qld. (coll. G.P. Whitley, v.1929 – see notes below); Rarotonga, Cook Islands (new record, RJB); Tokyo, Lake Biwa and Nagasaki, Japan (RJB); Jejudo, Korea (RJB, 2012).

Registration Nos.: E.g. ANIC RB.95.4.13; AM W2682 [the specimen's label says it is from Qld Museum grounds, Victoria Park, Brisbane collected by G.P. Whitley in May, 1924, identified by E. G. Easton (Jan. 1974) as "*M. javanica* (Kinberg)"; however, it appears to me to comply more with the page prior *M. californica* – see figures above. Moreover, in his review of Australian pheretimoids, Easton (1982: 731) reports material of *M. californica* (in the AM collection) from the grounds of Qld. Museum but does not

list *M. javanica*. In contrast, Jamieson (2000: 81) objects to Blakemore's (1999) query of that person's earlier report (viz. Jamieson, 1977: 294) of *M. javanica* from Queensland – unconvincingly offering W2682 as confirmation. In summary, Blakemore and Easton have no *M. javanica* in Qld. while Jamieson (1977; 2000) claims there is, but cannot substantiate it except by citing a mislabeled specimen. So we must disregard Jamieson's reports and, while also noting that mischievous persistence of misinformation wastes people's time, we can disconfirm *M. javanica* from the Australian faunal list (see also note about dishonesty above and of *L. terrestris* and *Argilophilus marmoratus* false reports as noted within this current work)]. Other material examined in ANIC Earthworm collection in Canberra and various collections in Japan.

Habitat: Riverbanks, under plant litter, in organic garden soil.

Behaviour: Very active escape and lashing response to handling.

Length: Current specimens 80-110 mm (cf Michaelsen, 50-125; Gates, 50-132).

Width: 3-5 mm.

Segments: 86-108 (cf. Michaelsen, 55-110; Gates, 85-115).

Colour: Anterior and dorsum dark red-brown with green/blue iridescence and darker mid-dorsal line, ventrum paler; clitellum buff.

Prostomium: Closed sometimes furrowed and tapering, or open epilobous.

First dorsal pore: 11/12 (or 12/13 in Jeju specimen).

Setae: Numerous ca. 20-60 and less dense in the anterior, e.g. 34/seg. 5; 46/seg. 9; 40-60/seg. 12; 62/seg. 26; aa is slightly wider than ab, ab is wider than bc, etc.; the anterior ventral setae in 2-9 are sometimes enlarged; setae are usually occluded on clitellum.

Nephropores: None found.

Clitellum: Annular on 14-16, occasionally just reaching into 13 and 17.

Spermathecal pores: Ca. 0.5 (Easton, 1981; 1982) or ca. 0.4 (Michaelsen, 1900) or ca. 0.3 or more (Gates, 1972) circumference apart, two pairs in 7/8/9; (rarely three pairs in 6/7/8/9 – see Remarks below).

Female pores: Single or closely paired in slightly raised crescent on 14.

Male pores: Ca. 0.3-0.4 circumference apart with ca. 13-15 setae usually interven, in small lateral slits of retracted copulatory pouches within generally tumid circular area of 18; sometimes penes evert on preservation (see Figs.).

Genital markings: None.

Septa: 4/5-7/8 moderately thick, 8/9/10 aborted, 10/11-13/14 thicker and thereafter thin.

Dorsal blood vessel: Single continuous on pharynx.

Hearts: In 10-13 (ventral vessel bifurcated under gizzard to 10).

Gizzard: Large, muscular and spherical in 8-9.

Calciferous glands : Absent (but oesophagus is dilated and vascularized in 11-13 and just dilated in 14 in Jeju specimen).

Intestine origin (caeca, typhlosole): In 14,15-16; caeca simple smooth or with slight dorsal and/or more usually ventral lobulation from segments 26,27 extending forwards to 25-23; (typhlosole low but broadly lamellar developing from 15-25).

Nephridia: Meroic as forests of equatorial tubules from 4 or 5, especially obvious on posterior septa of 5 and 6; (tufted nephridia in 5-7?). Beddard (1900a: 628) says there are vesicles on the nephrida after segment 30 (truely? or are they parasitic?).

Male organs: Testes/funnels holandric in 10 and 11 in sacs (sometimes more noticable in 11); seminal vesicles anteriorly in 11 and 12; pseudovesicles in 13 and/or 14 often unrecognized possibly because they are so rudimentary.

Ovaries: Small pair in 13; (ovisacs present in 14 or absent).

Prostates: Racemose in 17,18-20,21, thick muscular ducts loop to narrow exit; small penis present.

Spermathecae: In 8 and 9 [sometimes in anterior segment, i.e., in 7 and 8], large saccular ampulla with shorter duct from which thin twisted diverticular duct branches reaching as far or further than ampulla with club-like or ill-defined seminal chamber; (often whole diverticulum iridescent and may sometimes be flattened rather than round).

Gut contents: Colloidal soil and organic matter.

Notes: Found in high numbers in gardens at Brian Pastures, Gayndah and incidentally beside South Pine River, Samford; in both locations in organically rich soil. Trialled in the glasshouse during Blakemore (1994) studies but the results were inconclusive.

Remarks: Under ICZN, a genus is defined by its type-species. For *Metaphire* Sims & Easton, 1972 this is *M. javanica* which I believe to be similar, if not identical, to *M. californica*. Thus, in order to qualify for this genus a species merely has to conform to the characteristics as found in the type-species which, in this case, means that the male pores are simply non-superficial. Nevertheless, some current authors (e.g. James *et al.* 2005) yet misconstrue this simple fact and create eloborate but pointless explanations about depth of copulatory pouches required for membership of *Metaphire* thereby confounding their identifications and confusing students. The genus *Metaphire* was created for taxonomic convenience to break up unmanageable *Amynthas* that is defined by default mainly on its superficial male pores; it may yet have phylogenetic merit as,

rather obviously, the probable precursor to the more complex non-superficial male pores are just such simple pores.

Michaelsen (1900) allows *M. californica* specimens with an exta pair of spermathecae in 6/7 and Gates (1972) reports these only in single specimens: one each from Mexico and Hawaii. *Metaphire californica* is morphologically close to *Metaphire javanica*, distinguished mainly on the slightly wider reproductive pores in the former species, smooth intestinal caeca, according to Sims & Easton (1972) and a slightly longer, or rather un-folded, spermathecal diverticula. It is possible that these differences may be merged and the two may be synonymous, in which case *californica* may have priority as it is described before *javanica* on page 102 of Kinberg (1867), depending on First Revisor's act. Kinberg's description of *californica* (which included *A. corticis* in part) is:

> "Ph. californica *n. Cingulum segmenta 13-16 occupans; setae segmentorum anteriorum 40:nae, mediourum 50:ae, posteriorum 56:nae. In humo juxta Sausolita Bay et in scopulo juxta fretum prope urbem St. Francisco Californiae.*"

[**Start of *Metaphire hilgendorfi / Amynthas tokioensis* species-complex**

– End is here (at start of *Metaphire houlleti* spp-complex entry)].

***Metaphire hilgendorfi / Amynthas tokioensis* species-complex** *s*. Blakemore, 2003

Amynthas tokioensis species-group Sims & Easton, 1972: 237 (part). [Species group defined on intersegmental spermathecal pores paired in 6/7/8 and holandry. Members of the "*Provisional list of species or nominal species*-groups" (Sims & Easton, 1972: 214, 237) were: *acidophilus* (Chen, 1946), *axilis* (Chen, 1946), *candidus* (Goto & Hatai, 1898), *gomejimensis* (Ohfuchi, 1937), ***hilgendorfi*** (Michaelsen, 1892) (part – other parts were in a *youngi*-group and a *zebrus*-group), *immertus* (Gates, 1931), *japonicus* (Horst, 1883), *kanrazanus incertus* (laps. pro. *incretus*) (Kobayashi, 1937), *parvicystis* (Goto & Hatai, 1899), *rokugo* (Beddard, 1892), *shinkeiensis* (Kobayashi, 1938), *susakii patinus* (Kobayashi, 1936), *susakii susakii* (Kobayashi, 1936), *tappensis* (Ohfuchi, 1935), ***tokioensis*** (Beddard, 1892), *vividus* (Chen, 1946), *yunoshimensis* (Hatai, 1930) (part), plus *gucheonensis* Song & Paik, 1970 and *jiriensis* Song & Paik, 1971 were added by Easton (1979) and *koreana* Kobayashi, 1938 was included by Easton (1981) (in an *hilgendorfi* species-

complex). However, Sims & Easton's *tokioensis* species-group ignored that Sims & Easton (1972: 191) had found manicate caeca in *Amynthas tokioensis*, moreover *hilgendorfi* has priority, and all taxa were equally listed i.e., not synonymized].

Amynthas hilgendorfi species-complex Easton, 1981: 51 ["*included species*": ***hilgendorfi*** (syn. *rokugo, irregularis, schizopora*); *rokugo*; ***tokioensis***; *sieboldi* (non Horst, 1883); *vittata*; *schizopora*; *irregularis*; *agrestis*; *glandularis*; *levis*; *communissima* (syn. *sieboldi*); *sieboldi lenz*; *ambigua*; *yunoshimensis*; *tappensis*; *gomejimensis*; *gucheonensis*; *jiriensis*; *koreana*; *shinkeiensis*; i.e., *tokioensis* is now part of *A. hilgendorfi* spp-complex].

Metaphire hilgendorfi / *Amynthas tokioensis* species-complex Blakemore, 2003: 1, 7, 26; 2005, 2007, 2010 [current INCLUDED SPECIES are given below including *Amynthas dageletensis, A. koreanus*, *A. parvicystis*, *Metaphire soulensis*, and *Metaphire yamadai* as recent additions by Blakemore (2005, 2006, 2007, 2010)].

Composite diagnosis of *M. hilgendorfi* / *A. tokioensis* species-complex: Spermathecal pores absent, single or paired in some of 5/6/7/8 (mistakenly placed in 6/7/8/9 by Sims & Easton in parts of *A. yunoshimensis*) or 6/7/8 or 6/7 or 7/8 [cf. 7/8/9 in *Duplodicodrilus schmardae*]. Male pores absent, aberrant, or when present superficial (*Amynthas*) or non-superficial and sometimes in copulatory pouches (*Metaphire*). Genital markings absent, or as clusters of one or more papillated pores or as indistinct pigmented areas on pre-clitellar (near position of spermathecal pores) and post-clitellar (near position of male pores) segments – typically segmental, multiple mid-ventral in *M. hilgendorfi* or near intersegments and paired in *A. tokioensis*. Intestinal caeca non-simple, variably incised or manicate originating in segment 26 or 27. Body may be laterally striped with paler setal arcs (for *A. vittatus*), although this may be lost in preservation and was not described on some earlierl descriptions so is a rather uncertain characteristic for the group.

[**Note:** Apart from 'losing' spermathecae, the spermathecal diverticular bulbs of specimens identified with both *A. tokioensis* and with *M. hilgendorfi* in the current study have been found to vary, sometimes within a single specimen from one side to the other, from elongate to spherical – and in the latter case not filled with the usual white coagulum. The diverticula may therefore be likened to baloons that expand and elongate only when inflated following copulation. It thus appears that the actual

shape of the spermathecae, themselves often important taxonomic characteristics, may vary considerably in these parthenogenetic morphs and are thus uninformative].

Distribution: All the countries connected during the Pleistocene as recently as 10,000 years ago when the Bering and Korean Straits were landbridges allowing movement of terrestrial fauna: Japan, Korea, China and Russia - listed in Red Data Book for the Siberian Russian Federation from Kunashir Island in the Kurils adjacent to Hokkaido (Perel, 1978, 1997 and see Anon., 1997). Four taxa, *agrestis*, *hilgendorfi*, *levis* (= **syn. nov.** of *tokioensis*), and *vittatus* are reported as introductions into North America (Gates, 1954, 1958; Edwards & Lofty, 1977: 63; Easton, 1981: 53; Blakemore, 2005).

Reported (as *A. levis*) from Bac and Nui Provinces of Vietnam (Blakemore, 2007). A doubtful record is something claimed as '*Amynthas tokioensis* species-group' from central Thailand on the taxonomic authority of "*Assoc. Prof. Dr. Sam James*" by Somniyam & Suwanwaree (2009 *World Applied Sciences Journal* 6 (2): 221-226) that is possibly some other species complex as a *tokioensis*-group has been defunct since Easton's 1981 review and following Blakemore (2003, 2004) revisions.

Components of the *M. hilgendorfi* species-complex not recorded from Japan according to Easton (1979: 119; 1981: 52), are: *gucheonensis* Song & Paik, 1970 (sometimes misspelt "*guchonensis*" or "*gucheoensis*"); *jiriensis* Song & Paik, 1971; *koreana* Kobayashi, 1938; and *shinkeiensis* Kobayashi, 1938; to this list may be added the dozen or so Korean taxa with manicate caeca recently proposed by Hong & James (2001), Hong & Lee (2001) and Hong & Kim (2005), several probable synonyms, viz.:-

> *Amynthas yongshilensis*, *Amynthas alveolatus*, *Amynthas geomunensis*, *Amynthas eastoni*, *Amynthas boletiformis*, *Amynthas odaesanensis* , *Amynthas righii*, *Amynthas fasciiformis*, *Amynthas sanchongensis* by Hong & James (2001), and *Amynthas songnisanensis*, *Amynthas ephippiatus*, and *Amynthas multimaculatus* by Hong and Lee (2001), all having spermathecal pores in 6/7 and 7/8; and *Amynthas dageletensis* Hong & Kim, 2005 (in all its detail below).

All these names were mutually compared and differentiated, with scant consideration given to previous Japanese taxonomy in the last Century (see Michaelsen, 1900; Easton, 1981; Blakemore, 2000, 2002; 2003; 2005). Such useless namings move us further from the goal of resolving this species complex using the Principle of Priority.

Misidentifications and misnomers are yet commonplace.

Remarks: Blakemore (2010) remarked that resolution of the *Metaphire*

hilgendorfi/Amynthas tokioensis species-complex was one of the most pressing and seemingly intractable problems in Japanese / Korean (and Cosmopolitan!) earthworm systematics. DNA analysis (of types or neotypes from type localities, where known) was required for resolution and this has recently been accomplished in part for *hilgendorfi* (non-topotypic material from Korea) and possibly for *tokioensis*.

The unsatisfactory diagnosis above is based on the original descriptions, on information given by Michaelsen (1900), Gates (1954), and Easton (1981), and on the current author's observations of Japanese specimens. This revised diagnosis now accepts non-superficial male pores in copulatory pouches, and therefore *Metaphire* species, as several component taxa have this condition, including those samples of *M. hilgendorfi* that actually have male pores. [Cf. Gates' (1982: 52) incorrect attempt to classify male pores as "*non* invaginate"]. More work is obviously required to separate *Amynthas* species from *Metaphire* species, assuming that these genera are tenable, and to sort the parthenogenetic morphs into their respective taxa. Many species names have been precipitously created for parthenogenetic morphs and further synonymy is possible within this group. I concur with Gates (1958: 23) and Easton (1981) who stated that insufficient data are yet available either to establish the validity of the component taxa nor to recognize discrete subgroups, and, moreover, because male pores may be aborted with Easton (1979: 4) further commenting on the developmental stages of copulatory pouches in some pheretimoid species, thus recognition of the generic distribution of the taxa may also be problematical.

Despite Gates (1972: 95) saying that provision of names for all intermediate morphs is "*ridiculous*", many additional candidate 'species' names described by Japanese or Korean workers who appear mutually ignorant of previous work in either country (or elsewhere in the Wider World!), who also seem to prefer vernacular names.

Amynthas tokioensis has '*Metaphire*' *levis* and ?*A. paiki* as new synonyms, while *M. soulensis* (Kobayashi, 1938) and *Manus koellikeri* (Michaelsen, 1928) are restored and dubious species *A. defectus* and *A. dageletensis* are added to the group.

Amynthas vittatus may be distinguished on the basis of its characteristic banding.

Some Japanese studies on variability of genital structures, reproductive processes and breeding habits for parts of the *Metaphire hilgendorfi* /*Amynthas tokioensis* spp-complex were by Oishi(1930), Kobayashi (1937), Ohfuchi (1938a); Ochiai & Usuki (1988), etc. Nozaki *et al.* (2008) report on the eco-toxicology.

See also the excellent and detailed studies by Y. Sugi in Fukuoka, Kyushu.

'SPECIES' INCLUDED IN *Metaphire hilgendorfi* SPP-COMPLEX (key arrangement in **CHRONOLOGICAL ORDER** rather than alphabetically for reasons of priority and to allow progressive elimination of possibilities for identification):

Metaphire hilgendorfi (Michaelsen, 1892)

Fig. 2.2.1 *Metaphire hilgendorfi* compared with *A. agrestis* from Hatai (1930; figs. 1-3).

Perichaeta Hilgendorfi Michaelsen, 1892: 235, fig. 15. [Published in September, 1892 therefore has priority over Beddard's December, 1892 *P. rokugo* and *P. tokioensis*]. [From 'Japan' (Hakodate, Yokohama and possibly another locality). Michaelsen (1892) had these details:

Perichaeta hilgendorfi [Japan, Hakodate; No. 2123, Hilgendorf rp. (Typische Exempl. α und Exempl. γ und δ). Japan; No. 2144, Hilgendorf rp. (Exempl. ε). Japan, Yokohama; No. 2149, v. Martens rp. (Exempl. β)]. Types of five specimens of the original seven specimens (i.e., two missing) in Zoological Museum, Berlin listed by Hartwich & Kilias (1989: 266) after Michaelsen (1892: 237) thus:

"ZMB Verm. 2114: Japan; HILGENDORF leg. (1 Synytypus).
2123: Japan, Hakodate; HILGENDORF leg. (3 Syntypen).
2149: Japan, Yokohama; v. MARTENS leg. (1 Syntypus)]."

Hartwich & Kilias (1989: 266) list these types and, on page 268 list *Allolobophora japonica* that was also collected by Hilgendorf at Enoshima on 29.III.1875 – thus this is the possible type locality of the *P. hilgendorfi* syntype from "*Japan*". Although it is most probable that the **Typische Exempl. α** from Hilgendorf's Hakodate collection is the primary syntype thus the type locality is in Hokkaido.

Michaelsen (1892) had five "*varieties*" thus:

α - (150 mm long) with spermathecae opening in 6/7/8, GM 8 (No. 2123, three specimens from Hakodate);

β - spermathecae in 6/7/8, GM 8 and 9 (No. 2149, Marten's specimen from Yokohama);

γ - spermathecae 6/7/8, no GM (2123, one specimen from Hakodate);

δ - spermathecae 5/6/7/8, no GM (2123, one specimen from Hakodate);

ε - spermatheca on lhs in 7/8, GM paired, (No. 2114, from 'Japan').

Perichaeta rokugo Beddard, 1892b: 756, tab. 32, figs. 1-7 (published in December, 1892). [From "*Japan*" collected by Mr Masataka Rokugo (expected formulation may be "rokugoi", but under ICZN (1999) original spelling is to be maintained), stated types BMNH 1904:10.5.144-145, actually apparently now also recatalogued as BMNH 1974.1.166-167 "*1904:10:5 144/145 Perichaeta rokugo Beddard, 1892 Loc: Japan Coll: Mr Masataka Rokugo Ref. Zool Jahrb. Syst V6 p756*" inspected by RJB 2010 and again in 2013 – three previously dissected specimens that are a composite of two species – one is indeed *M. hilgendorfi* with GMs mid-ventral on 8, and two that have rows of two-three markings paired on 7 as found in *A. vittatus* (Goto & Hatai, 1898)]. Spermathecal pores in 6/7 and 7/8; genital markings central on 8; male pores and prostates absent, caeca manicate.

Pheretima hilgendorfi : Beddard, 1895a: 409 (syn. *rokugo*); Michaelsen, 1900: 271, 272; 313, 315, 317; 1916: 11 [syn. *rokuga* (laps. pro *rokugo*), *sieboldi*: Beddard, 1892: 759 non Horst, 1883: 191; 1899: 240 (= *Metaphire sieboldi*), *levis, ?agrestis, ?glandularis, ?schizopora*]; Beddard, 1900: 633, 634 (syn. *rokugo, irregularis* Goto & Hatai, *schizopora*); Hatai, 1930; Gates, 1954: 230; 1958: 11-13 (?syn. *yunoshimensis, glandularis*); Song & Paik, 1969: 15; Gates, 1982: 49; Ishizuka, 2000d; 2001: 61, 103 [syn. *glandularis* (misspelt "galndularis"), *rokugo* (both miscited as "*syn. n.*")].

[*Perichaeta schizopora* Goto & Hatai, 1898: 76 – see *Amynthas tokioensis*].

?*Perichaeta irregularis* Goto & Hatai, 1899: 13. [From Uwajima and Takahashi. Types unknown]. [Non *Perichaeta irregularis* Spencer, 1895: 53 (= *Perionychella irregularis*) from Tasmania, Australia. Note: under ICZN (1999: Art. 23.9.5) the junior primary homonym by Goto & Hatai (1899) is not replaced and prevailing usage is maintained as the two taxa have not been considered congeneric after 1899, e.g. Michaelsen (1900) at least had them in separate genera (see also Blakemore, 2000: 298)]. [Spermathecae, genital markings, male pores and prostates aborted (i.e., almost just a digestive "tube")].

Perichaeta glandularis Goto & Hatai, 1899: 18, figs. 9-11. [From "Takahashi (Prov. Bitchū)", now Okayama-ken. Type unknown]. [Spermathcae 6/7/8; genital marking patches mid-7 and mid-17/18]. *Pheretima glandularis* : Michaelsen, 1900: 315 (as a possible 'variety' of his *P. hilgendorfi*); 1906: 85 (as *species*

inquirenda); *Metaphire glandularis* : Sims & Easton, 1972: 238 (in a now defunct *Metaphire glandularis* species-group); Gates, 1954: 230; 1958: 11-13 (as possibly synonym of *P. hilgendorfi*); Easton, 1981: 51 (include separately in his *A. hilgendorfi* species-complex); Blakemore, 2003: 241; 2003: 29; 2005; 2007 (junior syn. of *M. hilgendorfi*). Notes: As with *Amynthas agrestis*, this taxon was thought by Michaelsen (1900: 315) a possible 'variety' of *P. hilgendorfi*, whereas Easton (1981) included it separately in his *A. hilgendorfi* species-complex. It is almost certainly a synonym of prior *M. hilgendorfi* as redescribed by Blakemore (2003, 2005, 2010, 2012: fig. 3 and a current paper under preparation based on Michaelsen's Berlin type-specimens – see below).

Amyntas hilgendorfi : Michaelsen, 1899: 9 (syn. ?*schizopora*); Beddard, 1900a: 633 (syn. *rokugo, irregularis, schizopora,* ?*glandularis*).

Amynthas hilgendorfi : Sims & Easton, 1972: 237 [partly in *tokioensis*-group, in *youngi*-group (that is mistaken as *P. youngi* that is a junior synonym of *A. glabrus*, actually has two pairs of spermathecae not just one pair) and partly in their *zebrus*-group]; Easton, 1981: 51 (appearing to accept Beddard's 1900 synonymy of *rokugo*, *irregularis*, *schizopora* rather than Michaelsen's synonymies).

Metaphire hilgendorfi : Blakemore, 2003: 241; 2003: 29; 2005; 2007 [comb. nov. (syn. *rokugo*, ?*irregularis*, ?*schizopora*, *glandularis*); sometimes yet mis-combined as "*Amynthas hilgendorfi*" more than a decade on, for example Hong & Kim (2009) and subsequently up to date; Blakemore, 2012: fig. 6; 2014].

Note: Named after collector, Dr Franz Martin Hilgendorf (1839–1904) who introduced Darwin's evolutionary theory to Tokyo, March, 1873 – Oct., 1876 (Ref.).

Distribution: From Japan, Korea (e.g. Koryo and Keijo) and Kunashir Island or Kuril group in Far East Russian Federation (Perel, 1997: 263; Anon, 1997) also reported as introduced into North America by Easton (1981: 53) from Gates (1954: 230) [from New York, Michigan, Middleburgh Virginia where they were used as food for certain Zoo animals] and Gates (1958: 12) [Lake Charles, Louisiana – possibly as escapees from greenhouses or spread by worm farmers and anglers]; recently from Bac and Nui Provinces of Vietnam (see Blakemore, 2007; https://www.researchgate.net/profile/Binh-Tt-Tran-2/publication/305626247.pdf).

Plus there is an unconfirmed report from Lee (1985: 164) of "*Amynthas hilgendorfi*"

being studied in Argentina by Gavrilov (1948) (the worm or the author from there?).

Diagnosis: Revised diagnoses of the various forms of this taxon from Michaelsen (1892, 1900; Gates, 1958 and pers. obs. of Japanese and Korean materials including Michaelsen's types) are: with spermathecal pores in 6/7 and/or 7/8, i.e., those specimens with spermathecal pores in 5/6/7/8 as in Michaelsen's Expl. δ (= *A. agrestis*) are no longer included [cf. Gates (1958: 13) who inappropriately included such morphs]; genital markings as presetal, central patches with several internal pore-glands corresponding in 8 and/or 9 (sometimes also in 10 and 11), and often in 17 and/or 18; intestinal caeca manicate. Male pores often aborted, when present at least sometimes non-superficial, may be shifted to 17 or 16 as well as on 18. *Perichaeta glandularis* was described by Goto & Hatai (1899: 18) with spermathecal pores 6/7/8, markings in 7 and 17/18 and figured with male pores in copulatory pouches (i.e., *Metaphire*), but in other regards complies with Michaelsen's α morph. Their description is problematical as the authors claim that secondary capsulogenous glands open near the spermathecal and male pores, whereas these are more usually associated with *Amynthas tokioensis* that typically lacks the central genital markings and has superficial male pores. Possibly this is an error by Goto & Hatai and may be taken as such unless anyone else can find a specimen that matches their description. As far as I am aware, nobody else has seen such an arrangement in any subsequent specimen and they may have combined two or more taxa in their diagnosis and figures (as with their other inconsistent descriptions).

Description of types and other Japanese/Korean material

Material examined: Types of five specimens of the original seven specimens (i.e., two missing) from Zoological Museum, Berlin were labeled *Pheretima hilgendorfi* 2123, 2149 and 2114 supplied in four sample jars (#1-4) as noted below and as published in Blakemore (2010). Tokyo An 427, "*Ph glandularis Sendai 1923-1925*", previously dissected mature, sketched (published Blakemore, 2012: fig. 3). Tokyo An 434, "*Ph. hilgendorfi Michaelsen Sendai* 1923-1925", mature specimen, sketched and dissected (published Blakemore, 2012: fig. 6).

In NHM, London Blakemore (2014) found Hamburg Museum specimens marked with red tape to indicate type material (none of which are the two of five types missing from Berlin):

1. Sample V.314 labelled "*O. Meg V314 Pheretima Hilgendorfi Mich. Hilgendorf Japan*" comprises one previously dissected specimen with its intestines loose in

jar; it lacks male pores and only has a spermathecal pore in 6/7rhs and GMs on 7lhs and 7rhs. This is here sketched, agreeing with *Amynthas vittatus* (Goto & Hatai, 1898).

2. Sample V.315 labelled "*O. Meg V315 Pheretima Hilgendorfi Mich. Hilgendorf Japan*" comprises one macerated, undissected mature; it lacks male pores and has spermathecal pores in 6/7/8 and GMs mid-ventrally on 8. This agrees with *Metaphire hilgendorfi* (Michaelsen, 1892).
3. Sample V.4008 labelled "*O. Meg. V.4008 Pheretima Hilgendorfi Mich 2 XII* [18]*95 Linz Nakahama*" comprises four specimens two previously dissected one of which is sketched here, that all agree with *Amynthas agrestis* (Goto & Hatai, 1899) as figured by Blakemore (2010: fig. 3lhs, that of fig. 3rhs may be a different species as the caeca differ) and see also Blakemore (2013a-e?: fig. 1).
4. Sample V.8508 labelled "*O. Meg V8508 Pheretima Hilgendorfi Mich. Vega Exp. Japan Fujiyama*" comprises one previously dissected mature with its intestines loose in jar; it lacks male pores and only has a spermathecal pores in 6/7/8lhs and GMs 7lhs and 7rhs. This also agrees with *Amynthas vittatus* (Goto & Hatai, 1898).

Blakmore, RJ. (2014) Miscellaneous earthworm types in the Natural History Museum, London (Annelida: Oligochaeta: Megadrilacea: Eudrilidae, Lumbricidae, Megascolecidae, Moniligastridae, Octochaetidae). *Opuscula Zoologica.* **45(2):** 199-155. [http://opuscula.elte.hu/PDF/Tomus45_2/2_Op_Blakemore_London_Museum_worms.pdf

Also in London Museum, as noted by Blakemore (2014), was:

Perichaeta rokugo Beddard, 1892d: 756, tab. 32, figs. 1-7 (published in December, 1892). [From "*Japan*" collected by Mr Masataka Rokugo, stated types BMNH 1904:10.5.144-145, actually apparently now also recatalogued as BMNH 1974.1.166-167 "*1904:10:5 144/145 Perichaeta rokugo Beddard, 1892 Loc: Japan Coll: Mr Masataka Rokugo Ref. Zool Jahrb. Syst V6 p756*" inspected by RJB 2010 and again in 2013 – three previously dissected specimens that are a composite of two species – one is indeed *M. hilgendorfi* with GMs mid-ventral on 8, and two that have rows of two-three markings paired on 7 as found in *A. vittatus* (Goto & Hatai, 1898)].

Korean IV0000261247, mature *A. hilgendorfi* specimen from Tongumi, Ulleungdo

dissected and figured, providing DNA sample w50. IV0000261248, a mature specimen from Arae-tongumi (one of several), its male field figured. IV0000261249, another mature specimen from Tongumi that lacks male pores and GM on 18 were samples from Ulleung-do, Korea published in Blakemore (2013a, b):

Blakemore RJ. (2013a) Jeju-do earthworms (Oligochaeta: Megadrilacea) - Quelpart Island revisited. Journal of Species Research 2(1): 15–54. www.nibr.go.kr/eng/event/journal_spe_3.jsp, 10.12651/JSR.2013.2.1.015

Blakemore RJ. (2013b) Ulleung-do earthworms - Dagelet Island revisited. Journal of Species Research 2(1): 55–69. www.nibr.go.kr/eng/event/journal_spe_3.jsp, 10.12651/JSR.2013.2.1.055

Notes: Revision is by Blakemore (2003, 2010, 2012b, 2012c: fig. 3 of "*M. glandularis*" = *M. hilgendorfi*, 2013a: fig. 6), full re-description based on types is now provided. The same person collected Beddard's *P. masatakae* and *P. rokugo* (see *M. hilgendorfi*), perhaps also from Tokyo.

Summary of Michaelsen's type material status and current state

Jar # - label of Kat. Nr and Origin/Status	**Michaelsen's exemplars (origin)**	**Current status of jar specimen**	**Previously dissected?***	**Condition of actual specimen**
#1-"*2123 1 Syntype!*"	α3 (Hakodate)	α3 SYNTYPE	No	Reasonable α3 syntype [DNA sample taken]
-	α2 (Hakodate)	MISSING	-	α2 MISSING
-	α1 (Hakodate)	MISPLACED	-	(α1 in #3-2149)
#2-"*2123 3 Syntypen!*"	γ (Hakodate)	γ SYNTYPE	Yes (see figure)	Mascerated γ syntype
#2-"*2123 3 Syntypen!*"	δ** (Hakodate)	SPECIMEN (ex δ syntype)	Yes (see figure)	Mascerated δ specimen**
#3-"*2149 Yokohama*"	β (Yokohama)	α1 SYNTYPE (β misplaced in #4-2114)	Yes (see figure)	Macerated α1 syntype (β in #4-2114)
#4-"*2114 Japan*"	ε***	β SYNTYPE	Yes (see	Reasonable β

	("*Japan*")	[ε syntype is missing]	figure)	syntype (ε MISSING)

* Michaelsen (1892) said he only dissected 4 of his 7 specimens, but he describes the internal anatomy of all five 'Exemplars', thus he must have dissected at least 5 spex.

**Ex. δ is now believed to be an *Amynthas agrestis* specimen.

***Ex. ε is MISSING from its jar but it is probably an *Amynthas tokioensis* specimen.

Summary table of Michaelsen's Type Specimen Characteristics

Exemplars	**Spermathecae**	**Anterior GMs**	**Posterior GMs**	**Male pores**	**Specific Status**
α	8	8	18	No (or Yes)	*M. hilgendorfi*
β	7 and 8	8 and 9	18?	No (or Yes)	*M. hilgendorfi*
γ	7 and 8	No	No	No (or Yes?)	*M. hilgendorfi*
δ	7, 8, 9	Patches 7-8 (pers. obs.)	No	No (or Yes)	Cf. *A. agrestis*
ε	7	Paired in 7	No (?)	No (or Yes?)	Cf. *A. tokioensis* or *A. vittatus*

Diagnosis: Size up to 155 by 8 mm. Segments 57-118. Colour in preclitellar dorsum is slate to dark brownish; not banded. Epilobous. First dorsal pore at 12/13 (not 11/12!). Setae ca. 43-65. Male pores, when present, in equatorial slits with ca. 15-20 setae between. Spermathecal pores, when present, nearly ½ C apart in 6/7/8. GMs as small circular papillae in groups mid-ventrally in some or all of 7-11, 17-22, usually in 8-9 and 17-18.

Septa 8/9/10 may be aborted. Intestinal origin in 15. Intestinal caeca manicate. Dorsal typhlosole simple lamelliform. Hearts of 10 lacking (always?). Spermathecae in 7 and 8. GM glands stalked and numerous, corresponding with the papillae.

Remarks: The list of included species in the "*Amynthas hilgendorfi* species-complex"

by Easton (1981) was fairly extensive and he appeared to accept the synonymies of A. *hilgendorfi* s. stricto by Beddard (1900) rather than those advocated by Michaelsen (1900). Studies by the current author have found specimens agreeing with *M. hilgendorfi* that have male pores (paired or single and sometimes displaced to segment 17 or 19) either in copulatory pouches or everted, and, if this is taken as the normal situation in amphmixic morphs, then this taxon belongs in *Metaphire* rather than *Amynthas*. Although Michaelsen (1900) had diagnosed this species with "*Prostates usually aborted, if present, similar to those of* P. sieboldi*, i.e. exiting directly without copulatory pouches*", *Metaphire sieboldi* was subsequently categorized as having copulatory pouches. Irrespective of whether morphs currently comply with *Metaphire* or *Amynthas*, the name *hilgendorfi* has priority within this species-complex group.

When Song & Paik (1969) surveyed Dagelet Island they found 10 species and also reported that although specimens of *P. hilgendorfi* from many districts of Korea seldom had male pores, 22 out of 23 specimens from Daglets Isl. evidently had both male pores and prostate glands.

Inexplicably, Ishizuka (1999a: 60) has both "*Perichaeta glandularis* : GOTO & HATAI, 1899" and "*Perichaeta rokugo* : BEDDARD, 1892" as **syn. n.**'s of *P. hilgendorfi* (Michaelsen, 1892) despite their earlier placings; and Ishizuka (1999a: 61) has both "*Perichaeta levis* GOTO & HATAI, 1899" and the prior "*Perichaeta schizopora* GOTO & HATAI, 1898" as **syn. n.**'s of his *P. irregularis* (Goto & Hatai, 1899) which he variously dates as either "1898" or "1899". In fact, Ohfuchi (1938a: 2; 1939: 81) had already combined *P. levis* (Goto & Hatai, 1899: 20) with *P. irregularis* (Goto & Hatai, 1899: 13) more than sixty years before. It is possible that the degraded morphs named *P. conjugata* by Ishizuka (1999b) are the same as *irregularis* as Ishizuka's figures of the deformed spermathecae are not much different to those shown in Ohfuchi (1938a: fig. 5) for his *P. koreana*. However, because *Perichaeta schizopora* and *P. irregularis* are such degraded morphs, they could actually be attributed to several taxa with manicate intestinal caeca and, in my opinion, both are possibly in synonymy of *A. vittatus* and/or *A. tokioensis*.

Gates (1954: 231) described typhlosoles and a series of dorsal saccular pit-like depressions to the intestine in some of 47/48-69/70 (as in *A. agrestis* too). Gates (1954: 233) also reported these worms are extraordinarily rich in vitamin B_{12} (*in litt*.).

Gates (1958: 13) had earlier said *Amynthas yunoshimensis* (Hatai, 1930) was indistinguishable (accepting an extra spermatheca or two in 5/6 as mere variations)

and thought it a synomym of parthenogenetic *P. hilgendorfi* but it seems it should be provisionally held separately on account of these extra spermathecae (if true).

Amynthas tokioensis (Beddard, 1892)

Fig. 2.2.2 *Amynthas tokioensis* (Beddard, 1892). Original sketch published by Blakemore (2010: fig. 2) of previously dissected type specimen showing spermathecae and glands in 7 and prostate ducting to rhs male pore *in situ* with a spermatheca found in a vial (from 8 rhs or lhs, other spermatheca missing from jar). Manicate intestinal caeca is from around segment 26 rhs. Enlargements are of male pore region (18 lhs) and spermathecal region (7 lhs). Clitellum is shown shaded.

Fig. 2.2.3 *Amynthas tokioensis* (Beddard, 1892). Original sketch by RJB of internal arrangement of spermathecal and male field of type specimen (not to scale). X - sites of previously removed genital gland, spermatheca, and prostate gland.

Fig. 2.2.3a of synonym *P. schizopora* cf. fig. 5b 2.2.3b modified from Ishizuka, 2001: 61 and Figs 2.2.3c (with segments miscounted?!) of probably synonym *P. surcata*, 2.2.3d of *P. verticosa*, 2.2.3e of *A. eastoni*, and 2.2.3f of *A. boletiformis*.

Perichaeta tokioënsis Beddard, 1892b: 762. [Published December, 1892 according to Michaelsen, 1900: 272]. [From Japan (probably Tokyo as in "tokioensis"). Lectotype in British Museum: BMNH:1904.10.5.166 inspected and designated by Sims & Easton (1972: 181, 191); re-inspected and refigured by RJB when on loan to YNU in October, 2004 and again in NHM, London in June, 2013; the specimen was 65 mm long with 67 segments but looks like a posterior amputee as the last segment has setae and is blunt rather than tapering. It is browny-grey in preservative and the clitellum is darker. The specimen had been dissected by Beddard and was slightly damaged: spermathecae in 8 were removed, only one remained in the jar that I put in a calcium vial along with a detached diverticulum, also the glands from 7rhs looked to have been removed, as was 18lhs prostate. The three labels inconsistenly state:

"*Perichaeta tokioensis*";

"*Pheretima tokioensis* (Bedd.) 1892 1904:10.5.166 Loc? Coll Beddard";

"*Perichaeta tokioënsis* Beddard, TYPE 1974.1.172 Loc. Japan Col. Mr Masataka Rokugo Ref. Zool. Jahrb. Syst. v6 p. 762".

Note: the same person collected Beddard's *P. masatakae* and *P. rokugo*, perhaps also from Tokyo].

[?*Perichaeta vittata* Goto & Hatai, 1898: 74. From Tokyo, Kamakura; no types. Markings, 3 pairs in 7 and 8; spermathecae absent or a single pair in 8;

prostates aborted. Described separately below as *Amynthas vittatus*].

?*Perichaeta schizopora* Goto & Hatai, 1898: 76. [From Tokyo. No types]. [Spermathecal pores in 7/8, the spermathecae in 8 irregular: the one on the left side had "*three diverticula*" (likely they mistook two copulatory glands for diverticula), that on the right the 'normal' single diverticulum; prostates aborted. Oviduct (female) pores were reported as "*one pair"*, *"entirely separate*", but either this is an abnormal specimen or, since this single aclitallate specimen was not fully mature (hence no genital markings), the absence of a tumid clitellum may cause the pores to appear separately. Either way, the presence of paired rather than separate female pores is not a particularly 'good' character and in every other reported respect, this 'species' resembles the current redescription of *A. tokioensis*].

?*Perichaeta irregularis* Goto & Hatai, 1899: 13 (not figured). [From Uwajima, western Shikoku, and Takahashi, that is adjacent to the north of Shikoku in Okayama-ken. No types]. [Caeca manicate but spermathecae, genital markings and prostates absent, therefore a highly degraded parthenogenetic morph that could belong to any number of similar taxa; cf. *M. hilgendorfi*, *A. parvicystis, A. tokioensis*].

?*Perichaeta parvicystis* Goto & Hatai, 1899: 18, figs. 8, 8a, 8b. [From Uwajima (Ehime-ken, Shikoku) and Oarai (Ibaraki-ken, Honshu). No types]. [See also its separate description below as "*Amynthas parvicystis*" and cf. *A. robustus*].

Pheretima parvicystis : Michaelsen, 1900: 316 ("*perhaps a variety of* P. tokioensis").

Perichaeta levis Goto & Hatai, 1899: 20, fig. 12. [From Takahashi Okayama-ken and Kumamoto (Kyushu). Syntypes recently found in Todai by Blakemore & Ueshima, 2011 registered as UMUTZ-Ann-Og-34]. [See also its separate description below as "*Amynthas levis*"]. [Spermathecae and copulatory glands exactly as in *tokioensis*, male pores and prostates absent, which is probably why Goto & Hatai found them "*difficult to recognize with the naked eye*"!; cf. *M. hilgendorfi*].

Pheretima levis : Kobayashi, 1938: 129 fig. 7. [From Korea; spermathecal pores in 6/7/8, genital markings paired in 8, male pores absent, caeca manicate - i.e., agrees with current redescription of *A. tokioensis*]; 1954: 230; 1958: 21-24 [from Bronx Zoo (from a tank where worms were raised to feed playtpus)

and a compost heap, Schenectady, New York, USA; some specimens athecal or partially so, caeca manicate; some specimens pale equatorially so look banded or striped; (?syns. some of *irregularis, ambigua, vittata, schizopora*)]; 1982: 54.

Amyntas (sic) *tokioensis* : Beddard, 1900a: 633 (syn. *candida* Goto & Hatai, 1998: 77; *parvicystis* Goto & Hatai, 1899: 18). [These synonyms were not universally accepted as the type of *tokioensis* was not previously known to have manicate intestinal caseca while the intestinal caeca of these other taxa are still rather uncertain].

Pheretima tokioensis : Michaelsen, 1900: 309, 316 (?syn. *parvicystis*).

Amynthas tokioensis : Sims & Easton, 1972: 237; Easton, 1981: 51; Blakemore, 2003a: 243 (syn. *verticosa*): Blakemore, 2003b: 7, 27, 43; (syns.?*parvicystis*, *verticosa*, ?*eastoni* Hong & James, 2001, ?*boletiformis* Hong & James, 2001 syns. nov.); Blakemore, 2005 [syns. ?*Perichaeta schizopora* Goto & Hatai, 1898: 76, ?*Perichaeta irregularis* Goto & Hatai, 1899: 13, *Perichaeta levis* Goto & Hatai, 1899: 20 (**syn. nov**. by Blakemore, 2006 with syns. ?*parvicystis*; ?*verticosa*; ?*Amynthas yongshilensis* Hong & James, 2001: 80), *A. eastoni* Hong & James, 2001: 83; *A. boletiformis* Hong & James, 2001: 84]; Blakemore, 2007 (same syns. plus ?*jiriensis* Song & Paik, 1971, *paiki* Hong in Hong, Lee & Kim, 2001 as **syns. nov**.); Blakemore, 2010 (same syns. plus ?*gucheonensis*, ?*dageletensis* & *sonjaesiki*); Blakemore 2012 (cf. *A. levis* as described below); Chang et al. 2014 (including syn. *levis*).

? *Pheretima gucheonensis* Song & Paik, 1970: 103. [From Korea (ref.). Types in Kyungpook National University, Taegu, Korea]. [Differs from the type of *A. tokioensis* mainly in the greater number of genital marking tubercles which number up to 1-10 by the spermathecal pores, and about a dozen by each male pore; obviously they are closely related, the question is how closely? Song & Paik compare their taxon to *P. tappensis* (Ohfuchi, 1935)].

?*Pheretima jiriensis* Song & Paik, 1971: 193. [From Korea. Types in Kyungpook National University, Taegu]. [Paired genital papillae are in 18, presetal, just close to the setal line; circular with slight central depression, equal to spermathecal GMs in size. Spermathecal pores just behind 6/7, 7/8. Genital markings small tubercles, two pairs, presetal in 7 and 8 near spermathecae. These markings correspond to those in *A. tokioensis* type, but the male pores

are figured as being in slightly enclosed pockets and thus require checking].

[?*Pheretima surcata* Ishizuka, 1999b: 48; 2001: 63 (cf. *A. tappensis*). [Tokyo].

Pheretima verticosa Ishizuka, 1999b: 50, figs. 75-83; 2001: 64. [Tokyo] – these two names now considered invalid –Blakemore (2010) and RJB Sept., 2017].

?*Amynthas yongshilensis* Hong & James, 2001: 80, figs 4A-C. [From Jeju-do Mt. Halla (Yongshil) Korea]. [Sympatric on Quelpart Island with *Amynthas alveolatus* Hong & James, 2001 that is exactly the same, i.e., synonymous, as *A. kanrazanus incretus* (Kobayashi, 1937) and comparable to *A. kanrazanus kanrazanus* (Kobayashi, 1937) that is itself similar to *A. tokioensis*].

Amynthas eastoni Hong & James, 2001: 83, figs 4M-Q (on page 80). [From Korea].

Amynthas boletiformis Hong & James, 2001: 84, figs 5A-E. [From Korea].

?*Amynthas paiki* Hong in Hong, Lee & Kim, 2001: 266, fig. 4. [From Korea].

Amynthas sonjaesiki Hong & James, 2009: 1243, fig. 8. [From Korea where its type is. Nothing in the description separates this from prior *A. tokioensis*].

Distribution: Japan and Korea; Hatai (1929) described it from Aomori, through Miyagi to Shikoku, and from Oshima and Kagoshima-ken also Oki, Tsushima and Yurushima. Reported from North America [by Gates (1954: 231) and as *Metaphire levis* by Easton (1981: 53), incorrectly as "*Metaphire levis* (Horst, 1893)", from North Carolina and Tennessee, USA by Wetzel (2005); and possibly as *Amynthas vittatus*, from Ashford, northeastern Connecticut by Schneider & McDevit (2002)].

Reported (as *A. levis*) from Bac and Nui Provinces of Vietnam (Blakemore, 2007). A doubtful record is something claimed as an "*Amynthas tokioensis* species-group" from central Thailand on the taxonomic authority of "*Assoc. Prof. Dr. Sam James*" by Somniyam & Suwanwaree (2009 *World Applied Sciences Journal* 6 (2): 221-226) that is possibly some other species-complex as a "*tokioensis* species-group" with simple intestinal caeca has been defunct since Easton (1981: 51) established his "*Amynthas hilgendorfi* species-group" and Blakemore (2003: 241) defined a "*Metaphire hilgendorfi*/*Amynthas tokioensis* species-complex" with characters redefined as noted herein.

Diagnosis: Colouration of the types is not well defined; in life it is brownish with iridescence and a white clitellum. Spermathecal pores widely paired ca. 5 mm apart compared to body diameter of 6 mm in 6/7/8 [or one or more absent Gates (1958: 22) and pers. obs. including a single specimen with no spermathecae nor anterior markings but with markings near superficial male pores in 18]; genital markings

paired just in front of the setal arcs on 7 and/or 8 (originally said by Beddard to be in 8 and 9 but more likely in 7 and 8 due to the position of the internal glands here and pers. obs. from the type) just medial to the spermathecal pores, with two or three glandular pores near to and medial to the male pores (all markings with various glands internally, those near the spermathecae may "*unite to open close to, if not in common with, the spermatotheca* (sic) *of segment VIII*" – Beddard, although I doubt they actually unite with the spermathecae and I know that Beddard missed some of the markings in the type). [Genital markings variable: sometimes extensive and sometimes absent]. Spermathecae "*of exactly the same form as in* Perichaeta rokugo" (= *M. hilgendorfi* i.e., with diverticula long and thin but widened proximally). The oesophagus of the type has several internal folds in 11-13 but lacks a typhlosole. Intestinal caeca now known to be manicate [see Sims & Easton (1972: 191) where they say "OTU 101 {i.e., *A. tokioensis*}, intestinal caeca ++ {where they meant "+++" = multiple or manicaete}" and pers. obs. of type and other specimens cf. Beddard] Gut contents of type was organic soil and coarse organic debis.

Ecology: Abundant under organic matter such as leaf litter; in greenhouses in USA.

Remarks: Beddard (1892b: 763) originally stated that "*there are only the usual two caeca in segment 26*" and so Michaelsen (1900) quoted the intestinal caeca form as "*usual*", but Sims & Easton (1972: 191), after inspection of the type, state it is "*multiple*" (= manicate) thus Easton (1981) included it in his *Amynthas hilgendorfi* species-complex. Michaelsen also thought that *A. parvicystis* (Goto & Hatai, 1899: 18) was possibly a 'variety' of *A. tokioensis*, allowing for errors in the original account such as the confusion of genital markings with spermathecal pores and *vice versa*. It is also possible that the various degraded morphs of *A. vittatus* and *A. tappensis* may also be synonymous, and therefore so too are all known synonyms of these taxa.

Following recent inspection of the type by the current author (RJB), we can now accept that the intestinal caeca are indeed manicate, and male pores (when present) are superficial; thus *Amynthas tokioensis* becomes the representative taxon of an *Amynthas tokioensis* species-group *sensu* Blakemore, 2003 currently combined, uncomfortably, within the "*Metaphire hilgendorfi/Amynthas tokioensis* species-complex", that would now be redefined to accept manicate species having "*spermathecal pores in 6/7/8, just in 7/8, or absent, and male pores pouched, superficial or absent*".

Easton (1979: 119) added *gucheonensis* Song & Paik, 1970 and *jiriensis* Song & Paik, 1971 to the *A. tokioensis*-species group of Sims & Easton (1972) that raised it to 20 nominal taxa - with many of these undecided synonyms. M.T. Ito (pers. comm. January, 2007) believed that *A. jiriensis* is also a synonym of *A. tokioensis*; and *A. gucheonensis* is another possible synonym (pers. obs. – see descriptions below).

Ishizuka's highly confused *Pheretima* (sic) *surcata* (with segments miscounted) and of *P. verticosa* largely comply with what is known of *A. tokioensis* and also with some of the possibilities, as noted under its account, in the highly confused description of *P. parvicystis* by Goto & Hatai (1899: 18) (and cf. *A. tappensis*). Figures accompanying Ishizuka's (2001: 61) redescription of "*Pheretima irregularis* (Goto & Hatai, 1899)" correspond closely what is known of Beddard's (1892b) earlier taxon having spermathcal pores in 6/7/8, glandular markings on 7, 8 and 18, and (now) manicate intestinal caeca, and may thus prove to actually be of *A. tokioensis*; (originally *P. irregularis* was based on specimens that lacked spermathecae, genital papillae and male pores!).

Hong & James' (2001) *A. yongshilensis*, *A. eastoni* and *A. boletiformis* also agree tolerably, with each other (or with *parvicystis* as then known) and thus are likely synonyms of *A. tokioensis* or, at the very least, would belong in an *A. tokioensis* species-group (- synonymy as per Blakemore, 2003: 43, addenda; 2005; 2007).

Similarly, ?*Amynthas paiki* Hong in Hong, Lee & Kim, 2001 agrees with *A. tokioensis* with spermathecal pores and GMs near 6/7/8, GMs near superficial male pores, and intestinal caeca manicate; nevertheless, they say it: "*appears to be closely related to* A. taebaekensis *Hong and James, 2001*", even though in this latter taxon (and perhaps somebody needs to check this?) intestinal caeca were stated as simple.

Nothing in the description of *Amynthas sonjaesiki* Hong & James, 2009 separates this nominal taxon from prior *A. tokioensis*.

[*Amynthas vittatus* (Goto & Hatai, 1898) (cf. *A. tokioensis* account above, this description in braces for clarity and comparison).

Perichaeta vittata Goto & Hatai, 1898: 74 (text sketch). [From Tokyo and Kamakura. Types?].

Amyntas vitattus : Beddard, 1900: 635.

Pheretima vittata : Michaelsen, 1900: 312; Cognetti, 1906: 783, figs. 8-11

(from Yokohama collected by Dr Haberer on 1.iv.1904 and deposited in Vienna museum); Hatai, 1929: 271, figs. 1-2; Ishizuka, 2001: 64.

Amynthas vittatus : Sims & Easton, 1972: 236 (*pomellus*-group with spermathecal pores in 7 & 8, but this obviously a mistake); Easton, 1981: 51; Blakemore, 2003; 2005; 2007.

Distribution: Japan and Korea; Hatai (1929) described it from Aomori, through Miyagi to Shikoku, and from Oshima and Kagoshima-ken. Also reported from Ashford, northeastern Connecticut by Schneider & McDevit (2002) but I don't know their source of identification.

Diagnosis: Banded colouration may appear due to dark dorsum with pale setal lines. Size about 100-155 mm. Spermathecae, at most, paired in 6/7/8 or one or more (or all) aborted; genital markings absent or in paired sets of one to six papillae linearly in 7 and often in 8 too just in front of setal line (rarely in 5 or 6 also), and similar markings sometimes near male pore(s), when present, on 18. Intestinal caeca manicate.

Remarks: Goto & Hatai's original description confused the pre-setal genital marking glands in 7 and 8 with spermathecae and thus falsely claimed 6 pairs in these two segments (parroted by Cognetti, 1906). Subsequently, Hatai (1929: 279) corrected his earlier flawed account and indicated that spermathecae may be present in some of 6/7/8. As noted under the account of *Metaphire hilgendorfi* / *Amynthas tokioensis* herein, it is possible that Goto & Hatai's subsequent *P. irregularis* is merely a more degraded morph of *A. vittatus* - or because it lacks banding, of some other taxon. Several variable specimens newly collected from Tokyo and/or Hokkaido and studied by the current author agree with *A. vittatus* and tend to have a similar banded colouration dorsally; they also merge characteristics with Goto & Hatai's *schizoporus* and *levis* (in all cases male pores were absent or superfical, i.e., not qualifying for *Metaphire* in fact nor by default). It is thus possible that all three taxa (*irregularis*, *schizoporus*, *levis*) are synonymous with *A. vittatus* or if the banding is distinctive only for *A. vittatus* (and *A. levis*?), then they may be more likely synonymous with *A. tokioensis*.

What is known is that the markings (when present?) on segment 7 and/or 8 are just in front of the setal arc and are in lateral series of one to three on each side. This may well be the most distinct characteristic, although when they are single, double, or missing [e.g. see Hatai's (1929: 280 fig. 2) twenty-eight kinds of variations of GMs] then this worm will presumable be similar to several other taxa, especially *A. tokioensis*, except for its characteristic banding, or *A. gucheonensis* that has more GMs.

In addition, Hatai & Ohfuchi's *M. servina* may also be closely related, if not synonymous, but with the male pores claimed to be in more defined pouches. Such possibilites require further investigation, but the over-riding consideration is the relationship of *A. vittatus* to *A. tappensis* and the relationship of both to the prior *A. tokioensis*, as discussed under that taxon above**]**.

Amynthas agrestis (Goto & Hatai, 1899)

Fig. 2.2.4a *Amynthas agrestis* (Goto & Hatai, 1899). Sketches of one of two specimens from Mishima, Shizuoka-ken collected by RJB in Tokyo Museum (An 420).

Fig. 2.2.4b *Amynthas agrestis* (Goto & Hatai, 1899). Sketches of one of three specimens from NMST (candidate neotypes).

Fig. 2.2.4c *Amynthas agrestis* (Goto & Hatai, 1899). Sketches of two specimens from bamboo grove, organic and other farms at Ami, Ibaraki-ken (near one of type localities, collected by author, 6th July, 2006) one without male pores and one with superficial male pores with complete prostate glands (it is possible this second specimen is a different species as it has variation in intestinal caeca from usual manicate to a pinnate form). All specimens in YNU collection. Original text-figure of spermatheca by (Goto & Hatai, 1899: fig. 7) for comparison.

Fig. 2.2.5 *Amynthas agrestis* compared with *M. hilgendorfi* from Hatai (1930; figs. 1-3).

Perichaeta agrestis Goto & Hatai, 1899: 17, fig. 7 (sketch of a spermatheca). [From Takahashi (Okayama-ken), Tokorozawa (Saitama-ken) and Oarai (Ibaraki-ken). Types unknown].

Pheretima agrestis : Michaelsen, 1900: 272, 313 ("*possibly a variety of* P. hilgendorfi"); Yamaguchi, 1930: 51, fig. 3; Kobayashi, 1938: 141; Gates, 1953: 5; 1954: 225-226; 1958: 1-3 (?syn. *hataii*); Hatai, 1930: 651, figs. 1-3; Yamaguchi, 1962: 25, fig. 10; Song & Paik, 1970: 102; Gates, 1982: 68 (he says male pores, when present, are in invaginations, but questions whether he has one or two species); Ishizuka *et al.*, 2000b: 179 [a highly confused description (even their synonymy is wrong and misses Hatai's crucial 1930 paper!); these authors have "*Three pairs of spermathecal pores in 6/7/8*" repeated as "*Three pairs of spermathecae on segments VIII-IX*" also with "*Male pores simple, superficial on segment XVIII, but rarely found*', thus a possible misidentification]; Ishizuka, 2001: 67, 103 (syn. *hataii*) [yet more errors].

Amyntas agrestis : Beddard, 1900: 637

Amynthas agrestis : Sims & Easton, 1972: 235; Easton, 1981: 51 (but not explicitly assigned to a genus); Blakemore, 2001 [syn. *striata* syn. nov.] 2005; 2007 [with *hataii* retained separately as per Sims & Easton (1972) and Easton (1981) – see *Metaphire hataii* (Ohfuchi, 1937: 13) comb.nov. provisionally restored from *Amynthas agrestis* synonymy]; Blakemore, 2010: 13 (syn. *striatus*, *minjae*).

?*Pheretima striata* Ishizuka, 1999b: 53, figs. 91-101. [From Mt Mitake, Hino City;

other material claimed from Institute for Nature Study, Itsukaichi City]. [Said to have large, stubby penes in 3% of specimens that extend from 17/18 to postsetal region of 18; but in Ishizuka (1999b: figs. 93, 99-101; 2001: 67, fig. 17.7a-7c) these are shown to be merely genital markings, probably indistinguishable from those shown on the same page by Ishizuka (2001: 67, figs. 16.7a-7c) for what he calls '*Pheretima agrestis* (Goto & Hatai, 1899)'. Said to be with pin-striped pattern of intersegmental furrows. Note: this name no longer considered to be valid due to failur to meet ICZN (1999: art. 11.4), Blakemore (2010)].

?*Amynthas minjae* Hong, in Hong, Lee & Kim, 2001: 264, figs. 2A-C. [Korea. Types, three specimens, stored in Keonbuk National Uni.].

Metaphire agrestis : Blakemore, 2003: 7, 28, (comb. nov., syns. *striatus*, *hataii* - the latter later reversed due to superficial male pores probable in senior synonym); Blakemore, 2013 (laps.). [*A. agrestis* now retained in *Amynthas*].

Material examined: Two matures Tokyo Museum registration NMST An 420 (both sketched and dissected) from Shirotaki-koen at Mishima, Shizuoka-ken, collected 7th VI 2010 by RJB and Yuko Hiramoto; plus specimens #5, #17 NMST An 431-433 three mature specimens (previously undissected, two here sketched and dissected); plus other Ibaraki-ken specimens collected by RJB from Bamboo grove, organic and conventional farms 6th VII 2006 (one with non-manicate caeca thus likely a different species).

Distribution: From Japan, Kuril Islands (Russian) and Korea (e.g. Hatai, 1930: 653; Kobayashi, 1938: 141; Song & Paik, 1970: 102; Hong *et al*., 2001: 265) and reported as introduced into North America e.g. by Davies (1954: 10) New Jersey (with *P. levis*), JHU Campus at Baltimore, Maryland (Gates 1952; 1954; 1958; 1982 who thought it introduced from Japan with imported materials possibly for Japanese Gardens), by Edwards & Lofty (1977: 63), also by Callaham *et al*. (2004) and Canada (Chang et al. 2014). Gates (1953: 5; 1954: 225-226) gives these details: Boston, Arnold Arboretum; New York City, aquarium building at the Bronx Zoo, September 1947 (as *P. agrestis* - these worms plus "*P. levis*" were being raised to feed the platypuses); Albany, NY in leaf mold and peat moss of a florist's nursery, July, 1948 (US National Mus. No. 108057); Baltimore and in the Arnold Arboretum at Boston (Gates, 1953b, pp. 5-8). Gates (1958) has Schenectady, NY from a compost heap, a lawn in Connecticut, and Shreveport, Louisiana - he also thought gardeners and anglers (using fishing bait) were extending its range. California reports are from containerized

plants at a nursery in Napa County in July, 2021 (Ref.). Later reports from USA unconfirmed as no diagnoses nor voucher specimens reported. A most recent study (Shultz *et al*. 2016) did not have the taxonomic expertise to correctly nor fully identify all their specimens (of "*A. agrestis*") thus their conclusions are somewhat invalidated.

Diagnosis: Dark brown dorsal pigment (i.e., unstriped cf. *vittatus, levis*) pers obs. and Gates (1958: 1). Size to 200 by 8 mm with ca. 100 segments. Dorsal pores from 12/13. Spermathecae paired in 5/6/7/8 (sometimes missing); markings as closely paired darker patches or puckered stripes on 7 and/or 8 and sometimes on 6 and 9, or "*without the modified patches*" (Goto & Hatai, 1899: 17 but how these were identified to this species is unknown). Male pores absent thus taxon defaults to *Amynthas*; however, in an Ibaraki specimen with tumid circular genital markings with central invaginated area present paired presetally on 18 that lack glands internally the male pores were superficial. [Male pores were mistakenly reported to be on penes (e.g. *striata*) or, when *P. hataii* was included in synonymy, to be slightly invaginated (i.e., = *Metaphire*), however in newly inspected material (R.J.B. pers. obs.) from Ibaraki-ken conforming to the type description the male pores were found to be small and superficial in setal arc below tumid genital markings (i.e., as in *Amynthas*) and thus *hataii* was removed from synonymy by RJB].

Intestinal caeca appear to vary in specimens from deeply incised or hemi-pinnate to manicate or almost complex, perhaps this latter condition is found in older specimens [a similar situation seems to occur in *M. yamadai* as Chen (1933: 259, fig. 21) shows variation from deeply incised to manicate caeca]. Gates (1954: 225) furether described typhlosoles and a series of dorsal pit-like depressions to the intestine in some of 44/45-75/76 (as in *M. hilgendorfi* too).

Ecology: Mainly superficial, leaf litter-layer dwelling species producing surface casts.

Gates (1954: 226) described posterior autotomy and numerous parasites.

Remarks: The original description of more than one hundred worms included a few specimens (from Oarai, Ibaraki-ken) that had a pair of large papillae presetally in 18, and a few others without the anterior genital patches that would, presumably, be indistinguishable, apart perhaps from convoluted spermathecal diverticula, from Goto & Hatai's subsequent *M. communissima* that is described separately below.

Hatai (1930: 653) states that according to Yamaguchi (1930) the majority of *A. agrestis* from Hokkaido possess male pores and similarly in Aomori-ken. However, details of the pores were not provided. Gates (1958: 2) also mentioned that Kobayashi

(1938) found two from 246 Korean specimens had both genital markings and male pores on 18 so that Gates believed specimens from around Sapporo would provide needed intermediate forms, although these would have to be compared to *M. hataii*. Although these two taxa were already combined by Gates (1958: 3) or retained separately, as *Amynthas agrestis* and *Metaphire hataii*, by Sims & Easton (1972), Easton (1981), and Blakemore (2010) on basis of a probable differences in the form of the male pores (where present), as described herein.

P. striata and *A. minjae* could be any of a number of prior species, if the authors had bothered to do the most basic of research, and published names cannot be ignored. *A. minjae* has incised caeca and defective spermathecae but may lack GMs.

Note: the name *P. striata* no longer valid due to failur to meet ICZN (1999: art. 11.4).

Barcode:

DNA from author's iBOLD JET project:

>JET027-10 [organism=*Amynthas agrestis* from Mishima] [NSMTAn420] COI partial

NNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNACTTATACTGGGTGCACCAGACATAGCTTTTCCA
CGACTCAATAATATAAGATTCTGATTACTTCCCCCATCTCTTATTTTATTAGTG
TCCTCGGCAGCCGTAGAAAAGGGTGCGGGAACANNNNNNNNNNNNNNN
NNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN

TGGGTGCACCAGACATAGCTTTTCCACGACTCAATAATATAAGATTCTGATT
ACTTCCCCCATCTCTTATTTTATTAGTGTCCTCGGCAGCCGTAGAAAAGGGT
GCGGGAACAGGATGAACAGTATATCCACCACTTGCAAGAAATATTGCACAT
GCTGGACCATCCGTAGACCTAGCAATTTTTTCTCTTCATCTGGCTGGTGCAT
CTTCAATTTTAGGTGCTATTAACTTTATCACCACCGTAATTAATATACGATGAT
CCGGATTACGTTTAGAACGAATTCCTCTATTTGTGTGGGCAGTTGTAATCAC
TGTAGTTCTCCTACTTCTATCTCTACCTGTTCTGGCTGGTGCGATTACAATAC
TCCTAACAGATCGAAATCTAAATACATCATTCTTTGATCCTGCAGGAGGAGG
AGANCCTATTTTATACCAACACTTATTC
Blast: 99-100% *Amynthas agrestis* from Japan, Kuril Islands and from USA (some of the latter data published - http://onlinelibrary.wiley.com/doi/10.1111/ivb.12145/epdf).

[*Amynthas parvicystis* (Goto & Hatai, 1899) (cf. *Amynthas tokioensis* above).

Perichaeta parvicystis Goto & Hatai, 1899: 18, figs. 8, 8a, 8b. [From Uwajima (Ehime-ken, Shikoku) and Oarai (Ibaraki-ken, Honshu). Types?]. Described with spermathecal pores in 6/7/8 – but maybe a mistake (as for *P. vesiculata* and as with genital markings in *P. carnosa*!)?

Pheretima parvicystis : Michaelsen, 1900: 316 ("*perhaps a variety of* P. tokioensis"); Kobayashi, 1941b: 259, 260.

Amynthas parvicyctis : Sims & Easton, 1972: 237; Easton, 1981: 56: Blakemore, 2003, 2005, 2007.

Distribution: Japan.

Diagnosis: Spermathecal pores stated to be presetal on 7 and 8, (or more likely in 6/7/8? or 7/8/9??). Male pores superficial on segment 18. Genital markings paired glandular pores near spermathecal pores (in 7 and 8) and usually with two pairs just median to male pores and sometimes another pair directly behind the male pores. Intestinal caeca simple incised (or possibly manicate?). Prostate glands aborted (always?).

Remarks: This species name, maintained separately by Easton (1981: 56), was thought a possible 'variety' of *Amynthas tokioensis* (Beddard, 1892) by Michaelsen (1900) now returned after its previous inclusion in the *Metaphire hilgendorfi* species-complex characterized by intestinal caeca that are manicate. *A. parvicystis* was originally described by Goto & Hatai with a single pair of caeca with the "*external margins frizzled*" and stated to be similar to the condition found in *Amynthas digitatus* (Benham, 1896) and *A. bonthainensis* (Benham, 1896), and Sims & Easton (1972: 173, Fig. 1I) show *A. digitatus* with multiple (= manicate) intestinal caeca although Goto & Hatai may not have known this. However, Goto & Hatai (1899: 23) failed to include *A. parvicystis*

in their list of species with manicate caeca (although they also miss their own *agrestis* and mistakenly include *divergens* in this list which may, however, be explained as it has tubercules on its caeca), and they had earlier overlooked the caeca of their *P. iizukai* and had misdescribed the multiple caeca of their *P. megascolidioides*. Yet Easton (1981) appears to have accepted that the caeca of *A. parvicyctis* were simple with incised margins. Almost certainly Goto & Hatai confused the position of the spermathecal pores with those of the genital markings (as they did both for their *P. obscura* and *P. vittata*). Moreover, Sims & Easton (1972: 237), for unexplained reasons, include *A. parvicystis* in their *tokioensis*-group characterized by spermathecal pores intersegmental in 6/7/8. Thus there is some ambiguity of the exact condition of caeca and spermathecal pores for this taxon.

Nothing matching the original description has been re-discovered thus far [except for a dubious report, just a tick in a column, by Kobayashi (1941b: 260) from Shikoku] and, if caeca are manicate, most likely it is merely a synonym of *A. tokioensis* [for which Ishizuka's *P. verticosa* is also a synonym with his figures (Ishizuka, 1999b: 50, figs. 75-83) complying almost exactly with Goto & Hatai's figures]. *A. masatakae* an erstwhile synomym of *A. robustus*, differs by having spermathecal pores in (6/)7/8/9 rather than 6/7/8, yet it has simple but incised caeca and a similar distribution of genital markings. Further work is required for resolution**]**.

[*Amynthas levis* (Goto & Hatai, 1899) (cf. *Amynthas tokioensis* above).

Perichaeta levis Goto & Hatai, 1899: 20, fig. 12. [From Takahashi Okayama-ken and Kumamoto (Kyushu). Types missing (Reynolds & Cook, 1976) but Syntypes recently found in Todai by Blakemore & Ueshima (2011) registered as UMUTZ-Ann-Og-34]. [Spermathecae and copulatory glands exactly as in *tokioensis*, male pores and prostates absent; cf. *M. hilgendorfi*].

Pheretima levis : Kobayashi, 1938: 129 fig. 7 [from Korea; spermathecal pores in 6/7/8, genital markings paired in 8, male pores absent, caeca manicate - i.e., agrees with current redescription of *A. tokioensis*].

?*Pheretima levis* : Gates, 1954: 234; 1958: 21 [from New York, New Jersey, USA].

Metaphire levis : Sims & Easton, 1972: 238 (*Metaphire glandularis* species-group).

Genus? *levis* : Easton, 1981: 51 (genus not stated within his "*Amynthas hilgendorfi* species-complex" but assumed to be *Amynthas* by default).

?*Metaphire levis* : Blakemore, 2003: 30; 2006; 2007.

Amynthas levis : Blakemore & Ueshima, 2011 (designation of syntypes). **Comb. nov.**. Blakemore 2012: 111, fig. 11 (cf. *A. tokioensis* above).

Distribution: Japan, Korea and reported as introduced into North America by Davies (1954: 10) New Jersey (with *P. agrestis*), Easton (1981: 53); Gates (1954: 234) – from the Bronx Zoo N.Y. where they were raised as food for platypuses, (Gates, 1958: 21) – from compost heap in Union College, Schenectady; and claimed from the Carolinas and Tennessee (where it is erroneously cited as "*Metaphire levis* (Horst, 1893)", - see http://www.inhs.uiuc.edu/~mjwetzel/AOGSMNP.PkChklst.html) - possibly a misidentification of a species that does have copulatory pouches. Recently reported from Bac and Nui Provinces of Vietnam.

Diagnosis: Spermathecal pores in 6/7/8 (or one or more aborted) surrounded by small papillae (or usually with one in front and one behind the pores) with glands internally (occasionally also in setal arc of segment 18 according to Gates, 1954); male pores and prostates typically aborted or vestigial; intestinal caeca manicate. Gates (1958: 21) described lack of pigment from equatorial setal arcs and thus a banded or striped appearance. Gates (1958: 22) recognized seven parthenogenetic strains, if pigment permitted identification (cf. *vittatus*). Note: New syntypes have uniform pigment.

Remarks: As the types and other specimens lacked male pores it is unclear how Sims & Easton (1972) or Easton (1981) could reliably transfer this taxon to *Metaphire*. Possibly this species name is in synonymy of *M. hilgendorfi* as was indicated by Michaelsen (1900: 272) [cf. Easton (1981) who appears to have maintained them separately], and is provisionally retained herein as *Metaphire levis* although it too may actually belong in synonymy of *A. vittatus*, or as Ohfuchi (1938: 2) thought: a synonym of the *irregularis* synonym. My current opinion from a syntype with a superficial male pore (Blakemore 2012: fig. 11) it 'defaults' back to *Amynthas* and is most probably in synonymy of *A. tokioensis* or, if the stripes are indicative, of *A. vittatus*. In newly designated syntypes pigmentation is a uniform brown thus the taxon, *A. levis*, is in most likelihood an *A. tokioensis* synonym].

Metaphire vesiculata (Goto & Hatai, 1899)

Perichaeta vesiculata Goto & Hatai, 1899: 21, figs. 13-15. [From Takahashi (Okayama-ken) and Oarai (Ibaraki-ken). Types not known. This taxon was compared, ridiculously, to "*P. sexta* Benham" that has spermathecal pores in 7/8/9 (rather than 6/7/8 as stated by Goto & Hatai, 1899) and its caeca are simple (rather

than manicate as stated by Goto & Hatai, 1899) and which is now in synonymy of *Metaphire javanica* (= *M. californica*)].

Pheretima vesiculata : Michaelsen, 1900: 312; Kobayashi, 1941: 259 ("*Ph. vesiculata=Ph. schmardae*).

Metaphire vesiculata : Sims & Easton, 1972: 238 (*Metaphire glandularis* species-group); Blakemore, 2003 (syn. *koellikeri* cf. Easton, 1981); 2005; 2007, 2010 (*koellikeri* restored as type of new genus *Manus* Blakemore, 2010).

[?*Pheretima köllikeri* Michaelsen, 1928 : 8, figs. 1, 2 (et P. *koellikeri*). From "Japan" and possibly Korea].

[?*Pheretima okutamaensis* Ishizuka, 1999b: 38, figs. 19-28. [Types in Tokyo. This taxon, fortunately no longer considered valid (Blakemore, 2010) is compared, ridiculously, to "*Eisenia foetida* Savigny, 1826" (sic)]].

[?*Pheretima biggiberosa* Ishizuka, 1999b: 40, figs. 29-37. [Types in Tokyo]. Ditto].

Distribution: Japan (and Korea?).

Diagnosis: Length 60-150 mm. Spermathecal pores in 6/7/8. Male pores within large copulatory pouches on 18 (without secretory diverticula internally although genital glands may be present). Genital markings absent (except internal to male pores). Intestinal caeca manicate: "*one pair of coeca with 4 pairs of secondary diverticula in XXVI; of these diverticula the dorsal ones are longest and reach segment XXIII*" (Goto & Hatai). (Nephridia absent from spermathecal ducts). Cf. *Duplodicodrilus schmardae* with spermathecal pores in 7/8/9, unless Goto & Hatai are mistaken?!

Remarks: Easton (1981: 60) tentatively included *Pheretima vesiculata* Goto & Hatai, 1899 in synonymy of *Pheretima (Parapheretima) koellikeri* (Michaelsen, 1928), but *P. vesiculata* has priority. Sims & Easton (1972: 238) had *Metaphire vesiculata* in a *Metaphire glandularis* species-group [other stated members were *glandularis* (Goto & Hatai, 1899), *levis* (Goto & Hatai, 1899), *servinus* (sic) (Hatai & Ohfuchi, 1937), and *soulensis* (Kobayashi, 1938)].

In this current revision, *Pheretima koellikeri* is removed from synonymy and established as a new genus similar to *Metaphire*.

Ishizuka (1999a: 65) has *P. vesiculata* (with spermathecae in 6/7/8) as "**syn. n.**" of *Duplodidodrilus schmardae* (with spermathecae in 7/8/9) although this was already mistakenly claimed by Beddard (1900a: 619) and Kobayashi (1941b: 259) had *Ph. vesiculata* in synonymy of *Ph. schmardae* (Horst, 1883), possibly from a cited reference of "*Nomura & Kobayashi, 1936*" that I have been unable to trace.

Metaphire communissima (Goto & Hatai, 1899)

Fig. 1.1.1

?Perichaeta sieboldi : Beddard, 1892: 759 (cf. *Metaphire hilgendorfi*; *M. sieboldi*).

Perichaeta sieboldii : Goto & Hatai, 1898: 65; Goto & Hatai, 1899: 23 [non *Megascolex sieboldi* Horst, 1883: 191; 1899: 240 (= *Metaphire sieboldi*)].

Perichaeta communissima Goto & Hatai, 1899: 23. [From "*Tokyo, Sendai, Tsugaru (south side of the Strait of Sangara), Shizuoka, Ibaraki, Bitchū; that is to say all over the Main Island*". Type material unknown].

Perichaeta sieboldi lenzi Michaelsen, 1899: 9. [From "*Central-Japan, Nakahama in der Prov. Setsu; LENZ leg. Aug.* [18]*95*." Types missing].

Pheretima communissima : Michaelsen, 1900: 262 [syn. ?*Perichaeta sieboldii* : Goto & Hatai, 1898: 65 (non *Megascolex sieboldi* Horst, 1883), *sieboldi* var. *lenzi*]; Ishizuka, 2001: 66.

Amynthas communissimus : Sims & Easton, 1972: 235 (syn. *sieboldi lenzi*); Easton, 1981: 51 (syn. *sieboldi* : Goto & Hatai, 1898.

Pheretima florea Ishizuka, 1999b: 52 [misspelt "*frolea*" in Ishizuka (2001: 66)]. [From Mt. Daibosatsu-toge (in Yamanashi-ken). Types, four of in National Science Museum, Tokyo] – this taxon no longer considered valid.

Metaphire communissima : Blakemore, 2007: 7, 28 (comb. nov.; syns. *sieboldi lenzi, florea*).

Taxanomic Remarks: In a footnote, Sims & Easton (1972: 235) state that: "*Both* communissimus *and* sieboldi lenzi *were provided for* Perichaeta sieboldi *: Goto & Hatai, 1898 (non Horst, 1883);* communissimus *has priority*". This was already established by Michaelsen (1900: 262), but appears to have been overlooked by Easton (1981: 51) when he listed *sieboldi lenzi* as a separate "*INCLUDED SPECIES*" in his *hilgendorfi* species-complex rather than as a synonym.

Horst (1899: 240) quite rightly roasts Goto & Hatai (1898) for their poor and inconsistent work 100 years before Ishizuka's contributions.

Material examined: NMST and UMUTZ specimens (Blakemore & Ueshima, 2011).

Distribution: Japan. Ishizuka (1999b; 2001) implies that geographical or topographic locations of his *P. florea* specimens coming from a Yamanashi-ken mountain is unique, but he appears to ignore the distribution of *M. communissima* given as from around Osaka, through Shizuoka, Tokyo, Aomori and Ibaraki, to Sendai in the north (or as

stated by Goto & Hatai: "*that is to say all over the Main Island*"), putting Yamanashi-ken just about smack in the middle of the known range.

Diagnosis: Spermathecal pores in 5/6/7/8; genital markings absent; male pores in small copulatory pouches; spermathecae with convoluted diverticula; intestinal caeca manicate.

Description of Neotype: Colour uniform puce in formalin with darker clitellum..Length 170 mm; segments 116; first dorsal pore 12/13. Septa 8/9/10 aborted, 10/11 onwards thin. Spermathecae in 6-8 with rugose ampullae and long, convoluted diverticula. Seminal vesicles large in 11 and 12. Ovaries in 13. Prostates in 17-20 with long, muscular duct and only small copulatory pouch. Last hearts in 13. Intestine from 15, caeca manicate, low lamellar ridge occurs dorsally after this.

Remarks: Differences from *M. sieboldi* – apart from spermathecal pores not in 6/7/8/9 – are the male pores are wider, almost lateral; and the spermathecal duct much longer in *M. communissima* compared to the short duct in *M. sieboldi*. Having male pores in slight inversions, rather than (everted?) "*on top of papillae*" as in the original description, just qualifies this taxon for inclusion in *Metaphire*. Michaelsen (1900: 263) stated that the prostatic ducts were thickened at the end but did not have (large?) copulatory pouches. The inadequate morphological characteristics used by Ishizuka to separate his *P. florea* from *M. communissima* (misspelt "*commnissima*") were a smaller body length, stated to be 60-70 mm, although he has misquoted as "150-250mm" the accepted range of *communissima* given by Michaelsen (1900: 262) as 90-250mm; and spermathecal ampullae stated to be "*shovel-shaped*" in *florea* as opposed to "*globular*" in *communissima*, even though Michaelsen (1900: 262) had stated they were "*flattened*". Ishizuka (2001: 66) redescribes *communissima* on the same page as his *florea* (misspelt "*frolea*"), here giving the respective lengths as 90-180 and 60-80 mm, and figuring other morphological criteria as being indistinguishable (apart perhaps from slight age-related differences). Both figured specimens appear to have male pores in copulatory pouches, supporting their inclusion in *Metaphire*, and are essentially indistinguishable, supporting their synonymy. Were there parthenogenetic specimens of *M. communissima*, lacking male pores, these would presumably be similar (synonymous?) to either *A. agrestis* or *M. hataii* specimens lacking genital makings. Thus, the relationship of *M. communissima* to the prior *A. agrestis* and subsequent *M. hataii* require resolution as their characteristics may overlap and merge.

Amynthas ambiguus (Cognetti, 1906)

Pheretima ambigua Cognetti, 1906: 782, fig. 7. [From Yokohama. Type in Vienna: 3979]. [Non *Pheretima barbara ambigua* Cognetti, 1913: 302 (= *Pheretima* (*Parapheretima*) *barbigua* Blakemore, 2004 replacement name under ICZN (1999: Art. 57.2 Examples))].

Amynthas ambiguus : Sims & Easton, 1972: 236, 240 (*Amynthas illotus* species-group); Easton, 1981: 51 (*Amynthas hilgendorfi* species-complex); Blakemore, 2003; 2005; 2007.

Remarks: Length ca. 95mm. Lacking spermathecae and prostate glands, but with manicate intestinal caeca. Gates (1958: 23) said "The type on which *P. ambigua* Cognetti, 1906, was erected is of an AR morph indistinguishable from *irregularis*" that he therefore included it under *Pheretima levis*. Really it is just another 'digestive tube' and could be anything, e.g. compare with *A. tokioensis*, *A. irregularis* and/or *Amynthas koreanus*.

[New genus under *M. hilgendorfi* / *A. tokioensis* spp-complex chronological synonymy list:].

Manus Blakemore, 2010

Type: *Pheretima koellikeri* Michaelsen, 1928.

Distribution: Japan (Kyushu?).

Diagnosis: Similar to *Metaphire* but with secretory diverticulum opening adjacent to each prostate gland; (single?) penial seta present; intestinal caeca manicate from 27.

Discussion: The genus has non-superficial male pores that define both *Metaphire* and *Pheretima* but lacks the nephridia on the spermathecal duct required for membership of the latter genus. The relationship of *Manus* to *Metaphire* is analagous to that of *Pheretima* to *Parapheretima* which is defined by its secretory diverticula opening to copulatory pouches. The secretory diverticula resemble tubular prostates but are presumed to be homologous in this relatively 'advanced' species. Other *Manus* members are not known despite several *Metaphire* species having stalked glands, rather than definite diverticula, adjacent to their male pores.

Etymology: Latin for "hand" for reasons explained by Blakemore (2010).

Manus koellikeri (Michaelsen, 1928)

Fig 2.2.6a. of male pore and a spermatheca after Michaelsen (1928: figs. 1, 2).

Fig 2.2.6b. Hamburg V6074 *M. koellikeri* types with enlargement of 8rhs spermatheca and boxed sketch of spermathecae, 18rhs prostate and manicate caecum of 2nd specimen.

Pheretima sp. (*Köllickeri* MICH. MS.) (sic - nomen nudum) Michaelsen, 1903: 100.

?*Pheretima köllikeri* Michaelsen, 1928 : 8, figs. 1, 2 (et P. *koellikeri*). [From "*Japan*". Types in Hamburg although collector, A. v. Kölliker, was working from Munich Museum. Alternatively this is a tribute to Rudolf Albert **von Kölliker**, (6 July - Zürich) 1817-1905 (2 Nov. - Würzburg) the Würzburg scientist and co-editor along with members of the von Siebold family who had collected in Japan and still had connections, of journal *Zeitschrift fur Wissenschaftliche Zoologie* in which Michaelsen often published. In this latter case the type locality may be the same as some of the Siebold specimens].

Pheretima (*Parapheretima*) *koellikeri* : Sims & Easton, 1972: 240; Easton, 1981: 60 (syn. *Pheretima* sp. Michaelsen, 1903, *??vesiculata*); Blakemore, 2005 (restoration as it has priority over *vesiculata*).

Metaphire koellikeri : Blakemore, 2007: 1, 20, 112, 125 (comb. nov.).

Note: name sometimes misspelt "kollikeri".

Material examined: V6074, the Hamburg types with modern label that states: "*Pheretima Köllikeri* Type material", comprises two specimens: one posterior amputee mature, previously dissected with most of internal organs removed such as gizzard, both lhs spermathecae and primary male organs except for part of 18lhs prostate gland; thus, since this is the only known type material, this is most likely the Lectotype. The second specimen was previously undissected but is immature, it was dissected by the current author (RJB) for the first time to confirm its identity since the primary type was so damaged. This latter specimen is a probable Syntype and thus eligible to be the Paralectotype. No other material is known to exist.

Distribution: 'Japan', but Sims & Easton (1972: 221) thought it possibly introduced; Easton's (1981: 60) distribution included Kyushu (from Kobayashi, 1941e: 513) but his other records were for his erroneous "*??vesiculata* Goto & Hatai, 1899: 21" synonym. Dr von Siebold resided at Nagasaki but this taxon seemed more common

on the island of Tsushima but it is now disappearing, as noted by Blakemore (2019).

Conservation status: This species has only been recorded once, by Kobayashi (1941e), since its original mention in 1903, its status must be classed as "rare" or "uncertain".

Disgnosis (from Michaelsen and from re-inspection of Syntypes): Types grey with clitellum buff in alcohol. Body with much secondary annulation. Length 148-164+ mm by 8-9 mm with ~100 segments (Michaelsen) [current 'Lectotype' 150+ with 80+ segments and immature 'Paralectotype' 170 mm with 140 segments]. Setae 37-57. First dorsal pore 12/13 (with that in 11/12 minute and poked by Michaelsen in 'Lectotype'). Male pore on penes invaginated within large porophores on 18 but extending across intersegmental furrows (Michaelesen). Spermathecal pores in 6/7/8 ca. 0.3 C apart [erroneously 0.4 C in Easton (1981: 60)]. Genital markings absent except for pads around spermathecal pores (current figure) and probably those internal to secondary male pores (Michaelsen figure). Septa 8/9/10 are apparently absent in both types. Holandric with seminal vesicles anteriorly in 11 and 12. Remains of oesophagus in 13 with ovaries and last hearts plus an anterior pair of pseudovesicles remain in the type. Prostates racemose in 17-22 (in 'Lectotype' 18rhs only remaining) each ducting to penis within copulatory pouch confined to body wall with accessory secretory diverticulum opening anterior to male pores and associated with penial seta. These diverticula resemble tubular prostates and extend to segments 17 or 16. Spermatheca with diverticulum shorter than ampulla and Michaelsen shows one with zig-zagging diverticular bulb; in contrast, the current 'Lectotype' had flat, rather compact bulbs on short only slighly wavy stalks. Both diverticula stalk and spermathecal duct are muscular and no nephridia are attached (pers. obs. and Michaelsen, fig. 2). Intestinal caeca manicate (confirmation) and gut contains yellow soil and coarse organic matter in type; typhlosole not found. Nematodes and monocystis cysts found in type (plus a red eyelash, possibly Michaelsen's?).

Remarks: Easton's synonymy of *Pheretima koellikeri* with *Metaphire vesiculata* had assumed this species lacked nephridia on the spermathecal ducts (Michaelsen's fig. 2 does not show any, and their lack was confirmed from types), and that *M. vesiculata* lacked them too (but had secretory glands?). Goto & Hatai (1899: fig. 15) did not describe any such glands for their *P. vesiculata* and, moreover, a usual characteristic of *Metaphire* is having stalked glands, rather than secretory diverticula, on the copulatory pouches (Sims & Easton, 1972: 215, 221).

Sims & Easton (1972: 222) only provisionally placed *koellikeri* in the

subgenus *Pheretima* (*Parapheretima*) because Michaelsen (1928:11) had remarked on its similarity to other members that also had secretory diverticula on their copulatory pouches; yet presence of nephridia on the spermathecal diverticula would be reqired for membership and these are now known to be absent. This species was provisionally placed in *Metaphire* by Blakemore (2007) and it was noted that it may merit allocation to another, possibly new, genus on the basis of its secretory diverticula to the male pores. This action is taken here.

Differences from Michaelsen's original description (and Easton's that included *M. vesiculata* in part) are that the current type has large flat pads around the spermathecal pores, possibly these have some corollary function to the secretary diverticula and penial setae of the male pores. Moreover, the spermathecal diverticula differ from Michaelsen's rendition as the muscular stalks are not as short and the bulb not as zig-zagged as shown in his possibly artist's impression figure.

It was previously thought to resemble parts of the *M. higendorfi* spp-group may now be separated.

Possibly its origin and further materials may be sought in southern Japan where other of Siebold's specimens were obtained, but this is rather speculative

[*Amynthas*? *yunoshimensis* (Hatai, 1930) (cf. *M. hilgendorfi*).

Pheretima yunoshimensis Hatai, 1930b: 655, figs. 4 (of body), 5 (of defective spermathecae and internal capsulogenous glands). [From Sapporo, Hokkaido and Aomori, northern Honshu where Yunoshima is a small island off Asamushi township. Types unknown]; Gates, 1958: 13 (as part of *hilgendorfi*); Ishizuka (1999a: 67) [name misspelt "*yunoshimaensis*"]; Ishizuka, 2001: 105 [name misspelt "*yunishimaensis*"].

Amynthas yunoshimensis : Sims & Easton, 1972: 237; Easton, 1981: 52; Blakemore, 2003; 2005; 2007.

Remarks: From Japan. Genital markings as composite papillae in 8 and 18. Due to the original description allowing spermathecae in either 6/7/8 or 5/6/7/8, Sims & Easton (1972: 237) had this taxon partly in an *Amynthas tokioensis*-group with spermathecal pores in 6/7/8, and partly (lapsus?) in an "*Amynthas sieboldi*-group" with spermathecal pores in 6/7/8/9, accordingly this latter condition is not included in the *hilgendorfi*-complex diagnosis above (cf. Easton, 1981). Spermathecae appear

mostly defective. Male pores were present in a specimen from Sapporo (Hatai, 1930: 656) but their form was not described and this taxon is poorly differentiated from *M. hilgendorfi* with which it shares patches of central genital markings in 8 and 18. In fact, Gates (1958: 13) had earlier said it was indistinguishable (accepting an extra spermatheca or two in 5/6 as mere variation) and thought it a synomym of *hilgendorfi*].

Metaphire yamadai (Hatai, 1930)

Pheretima yamadai Hatai, 1930b: 664, fig. 8. [From Tottori, Okayama, Wakayama, Kobe and Hatta (Ishikawa-ken). Types unknown although description originally based on "*a very large number of these from both Tottori and Okayama through the courtesy of Prof. GENTARO YAMADA of the Tottori Government Agricultural College*" and Kobayashi, 1939 inspected "*Three cotype-specimens with clitellar glandularity not yet complete, Tottori, Japan, May, 1930*].

?[*Pheretima pectinifera* Michaelsen, 1931: 15 [From Soochow. Types missing]; Chen, 1933/36 (syn? *yamadai*); Gates, 1935 (at least four of the Hamburg specimens labelled as *Ph. pingi* are obviously *Ph. pectinifera*); Gates, 1939: 460 (very confusing partial synonymy involving bits of *pingi* and bits of *yamadai*].

Pheretima yamadai: Chen, 1933: 255, figs. 20-21; Gates, 1935: 13-14 (?syn. *pectinifera*; non *yamadai* A-form (= *Ph. tschilliensis*) Chen, 1933); Gates, 1936: 272 (syn. ?*pectinifera*); Kobayashi, 1939: 135 [syn. *pectinifera* ; *yamadai* B-form Chen, 1933, non *yamadai* A-form Chen, 1933 (= some species distinct from both *yamadai* and *tschiliensis*)]; 1941a: 51; b: 260; c: 376; e: 513; Gates, 1948: 13.

Amynthas yamadai: Sims & Easton, 1972: 237 (*Amynthas sieboldi*-species group).

Metaphire yamardai: (sic lapsus pro *yamadai*) Easton, 1981: 60 (syn. *soulensis* - but this is not accepted here)

Metaphire yamadai: Blakemore, 2003: 43, addenda; 2005; 2006; 2007 [suggesting synonymy of Korean *Metaphire quelparta* (Kobayashi, 1937), *M. sanseiana* (Ohfuchi, 1951: 56), and the probable **syn. nov.** of the latter species, *M. indigo* (Ohfuchi, 1951: 58)]; Blakemore, 2010a: 16 (as part of *M. hilgendorfi* /*A. tokioensis* spp-complex – this now perhaps less justified); Blakemore, 2012: 117, fig. 15 (neotype).

Material examined: Neotype, An 448; mature, previously undissected mature labelled: "*Ph yamadai* [kanji for 'collected from Tottori-ken']. Unfortunately no date is given

thus, despite being from type locality, it is not certainly a syntype. [Note: other currrently unregistered specimens stored in NMST from Saito Ho-on Collection are comparable, viz. #174, 816, 867-874, pers. obs.].

Distribution: Japan, China (Soochow, Nanking, Chusan, Shuan-shan and Ning-po – from Kobayashi), ?Korea (Easton, 1981: 60 states "*Japan, China, Korea*", but Korea is probably just for his *soulensis* synonym; Kobayashi (1939) has *yamadai* in both Japan and China likely for the *P. pectinifera* synonym determined by Chen (1933).

Diagnosis: Length average 127 mm (cf. 210 mm *pectinifera*); neotype 130 mm with 106 segments and ca. 80 setae on 12. Spermathecal pores in 6/7/8/9 (ca. 0.43 U apart – Easton, 1981). Male pores at extreme margins on distended segment 18 within small copulatory chambers that are mostly everted by preservation (normally retracted and thus "non-superficial") occuping 17/18-18/19 and with up to 32 setae between. Genital markings small, and variably median to spermathecal pores on 7 and 8 (according to Easton and Kobayashi but overlooked by Hatai and found in current studies to be in 6-8 possibly as parasitic artefacts) and GMs also median to male pores and within copulatory pouches (*pectinifera* has additional markings in several longitudinal ranks median to level of spermathecal pores in 7-9). [Neotype has 'rogue' markings in 6rhs, 7lhs and 8rhs that may possibly be parasitic artefacts]. Spermathecae are as figured with small glands associated. The muscular duct of the large prostatic gland of the neotype disappears into a small cavity on the body wall and no genital marking glands appear in this site although glands correspond with the more median cruciate markings. Intestinal caeca manicate (or the exact quote: "*in XXVIII the finger shaped coeca* [sic] *with five projections are found in pairs*"); [Chen (1933: 255-261, fig. 21) has "*caeca lobulated in 27-24 or 23(22), with parallel lobes or vertically tooth-shaped diverticula*" and figures manicate caeca (but this was a misdescription according to Gates, 1948: 13)]. The neotype manicate caeca has a longer lobe that is much incised on its outboard edge.

Remarks: Some accounts (erroneously?) have spermathecal pores in "5/6/7/8" despite them being described as in 6/7/8/9. Regarding male pores, Kobayashi (1939: 138) says:

> "*The general appearance of the male segment of this species resembles those of* Ph. asiatica, Ph. tibetana, Ph. tschiliensis, Ph. aggera, Ph. grahami, Ph. praepinguis, Ph. vulgaris and Ph. quelparta *; in each of these species there are found in the ventrolateral position of the copulatory chambers provided with*

crescent-shaped secondary male pores, and each of these chambers contains internally a male disc and a primary male porophore. On the male disc, some setae are always planted and some genital papillae are usually found."

Thus, although the male pores appear superficial in preserved specimens, they are classifiable as in copulatory pouches and thus just qualify this species for *Metaphire*. This taxon was a new combination in the *M. hilgendorfi* species complex by Blakemore (2007, 2010a) but probably, on basis of current redescription, merits separate status.

Metaphire yamadai (Hatai, 1930) is almost exactly similar superficially to *M. aggera* (Kobayashi, 1934) that differs in its simple but incised intestinal caeca (misdiagnosed in *A. aggera*?), and Kobayashi (1938a: 155, 157) says that his *P. aggera* is close to, and may be synonymous with: ?*Metaphire tschiliensis* (Michaelsen, 1928), its synonym *Metaphire kiangsuensis* (Chen, 1930) from Chen (1933: 250), and with his own *Metaphire quelparta* (Kobayashi, 1937). Depite having simple, incised caeca, *M. quelparta* is almost exactly the same in each described character except for its large saccuar bodies associated with the spermathecal pores, but it may belong in synomymy nevertheless along with *M. sanseiana* (Hatai, 1951: 56) and the probable syn. nov. of the latter species, *M. indigo* (Hatai, 1951: 58). – research for this is pending.

For *M. yamadai* from China, Chen (1933: 259, figs. 20, 21) shows variations with the caeca either deeply incised or manicate, but this was likely a misdescription by Chen of a composite of both Michaelsen's *P. pectinifera* and *P. tschiliensis*. This latter taxon may indeed have incised caeca and is currently classified as ?*Metaphire tschiliensis*.

Easton (1981)'s inclusion of *Metaphire soulensis* (Kobayashi, 1938) in synonymy of *M. yamadai* (Hatai, 1930) is not here supported, as there are notable differences in morphology, especially of the markings around the male pores (when present). Thus, *M. soulensis* is maintained separately and has *M. shinkeiensis* (Kobayashi, 1938) and *"aokii"* (Ishizuka, 1999) included as its junior synonyms, as clearly stated and shown by Blakemore (2003, 2010a, 2012, 2016, etc.).

Amynthas defectus (Gates, 1930)

Fig. A4 from Thailand ex Pattna thesis (2008: 126).

Pheretima defecta Gates, 1930: 308. [From Labaw, Myanmar. Types none].

Pheretima defecta : Gates, 1960: 255 (syn. *jacita*); 1972: 176.

Pheretima jacita Gates, 1931: 391. [Ye, Myanmar. Types none].

Amynthas defectus : Sims & Easton, 1972; Blakemore, 2005 (syn. *jacita*).

Distribution: Myanmar peninsular and northern in jungles away from towns; Thailand.

Remarks: This species was erected on an athecal posterior amputee lacking prostates but with male pores and manicate intestinal caeca. Genital markings absent. It was later stated (Gates, 1960; 1972) to have up to three pairs of spermathecae widely paired in 5/6/7/8 and superficial male pores each in elongate glabrous (i.e., smooth) area on 18 not extending into adjacent segments, with other morphs lacking spermathecae and/or prostates and thus it is probably associated with the *M. hilgendorfi* / *A. tokioensis* spp. group (cf., *A. illotus* spp-group).

Amynthas tappensis (Ohfuchi, 1935)

Pheretima tappensis Ohfuchi, 1935: 409, figs. 1-5. [From Tappi, Higashi-Tsugaru district, Aomori northeast Honshu - the closest point to Hokkaido. Types unknown].

Amynthas tappensis : Sims & Easton, 1972: 237; Easton, 1981: 52; Blakemore, 2003; 2005; 2007 (syns. as below).

Pheretima bimaculata Ishizuka, 1999b: 42; 2001: 60. [Tokyo] – invalid taxon.

Pheretima silvatica Ishizuka, 1999b: 46; 2001: 63. [Types in Tokyo] - Ditto.

[?*Pheretima surcata* Ishizuka, 1999b: 48; 2001: 63 (cf. *A. tokioensis*). [Ishizuka (2001: 63) has miscounted segments and erroneously states spermathecal pores are in "*5/6/7*" although the original description, and all figures, show them in 6/7/8! Types in Tokyo] - Ditto.

Amynthas odaesanensis Hong & James, 2001: 86, figs. 5F-H. [From Korea].

Amynthas righii Hong & James, 2001: 87, figs. 5I-L. [From Korea].

Amynthas fasciiformis Hong & James, 2001: 89, figs. 5M-O. [From Korea].

Amynthas sanchongensis Hong & James, 2001: 90, figs. 5P-T. [From Korea].

Distribution: Japan, Korea. More than sixty years ago, Kobayashi (1941c: 380) reported *Ph. tappensis* from Kinki, through Kanto to Tohokku regions of Honshu, i.e., much of central and nothern Japan, well encompassing the range of all of Ishizuka's specimens. Hong & James appear to have again ignored all previous Japanese work.

Diagnosis: Size 40-208 mm, segments 54-115, setae 32-64. Brown dorsum. Male and spermathecal pores ca. 0.4-0.5 circumference apart with about 16-25 setae

between male pores. Spermathecal pores in 6/7/8 (typically). Genital markings as one or more small papillae posterio-median to position of spermathecal pores in some or all of 7-8,9 (probably) and anterio-median to relative position of male pores in some or all of 17-19,20. Spermathecal diverticula convoluted. Intestinal caeca manicate.

Remarks: Descriptions of all three of Ishizuka's species are highly confused regarding the location of spermathecal pores and distribution of genital markings, but all are mutually similar, allowing for natural variation, and they all also resemble *Amynthas tappensis* (Ohfuchi, 1935) thereby possibly qualifying for synonymy with it in *A. vittatus* (Goto and Hatai, 1898) - see also *A. purpuratus*.

Examples of the confusions are that the Ishizuka's description of *bimaculata* has markings stated in 9-10 and spermathecae in 6/7/8. But his Fig. 38 shows markings in either 8-9 or 9-10, and his fig. 39 has them in 7-8 [this same figure is copied in Ishizuka (2001: 60, fig 3a) but now has them in 8-9 and spermathecae in 7/8/9]. Moreover, his description of *surcata* had spermathecal pores quite clearly stated to be in 6/7/8 (spermathecae in 7 and 8), while the markings were said to be presetal in 7-8 and in 18. Yet his Fig. 65 possibly has the segments miscounted, and Fig. 66 show spermathecae in 5/6/7 and only one marking in 7 (or is the legend wrong?). Also the key in Ishizuka (1999b: 55), apart from having "*markings absent*", has "*genital glands complex duct type*" (even though they are stated in the description to be either simple **or** complex in both his *silvatica* and *surcata*) and in the next couplet he confuses *surcata* with *verticosa*, albeit they may indeed be identical species, both belonging in *A. tokioensis*. Unremarkably, these latter errors in the figures are perpetuated in Ishizuka (2001: 60, 63).

Ishizuka's *silvatica* which was based on either 9 or 10 specimens, may differ slightly in having first dorsal pores in 11/12 rather than 12/13 (normal variation?) and seminal vesicles given in the unlikely location of 10-11 rather than 11-12 (albeit the figure legend for these is also mis-scaled), and these may just as easily be miscounts.

Hong & James' *A. odaesanensis*, A. *righii*, *A. fasciiformis* and *A. sanchongensis* are all mutually compared, agree with each other, and fall within variation of Ishizuka's specimens and thus are also likely synonyms within the ambit of *A. tappensis*. The latter species, *Amynthas sanchongensis*, is even described with "*eight of sixteen*" specimens lacking genital markings near the spermathecal and male pores and therefore, presumably, almost impossible to distinguish between *A.*

tokioensis and/or *A. tappensis* specimens that also lacked markings. Hong & James (2001) compared this latter species of theirs only with the sympatric *A. jiriensis* (Song & Paik, 1971) saying "*it differs in the shape of male pore region and the genital markings...*"; I take it that they meant to add "...**when these are present!**...".

The real question – despite all this distraction and diversion – is relationship of *A. tappensis* to the prior *A. tokioensis* and *A. vittatus* and these to the ilk of *M. soulensis*.

Metaphire hataii (Ohfuchi, 1937).

Fig. 2.2.7 *Metaphire hataii* (Ohfuchi, 1937) based on original figures.

Pheretima hataii Ohfuchi, 1937a: 13, fig. 1. [From Kyu-sakurayama near Morioka, Iwate-ken. Types unknown.]

?*Pheretima agrestis* : Kobayshi (1938: 142, 145); Gates, 1958: 3 (?syn *hattai*).

Pheretima hattai : Gates, 1958: 3 (as part of *P. agrestis* description).

Metaphire hataii : Sims & Easton, 1972: 238 (*birmanica* group); Easton, 1981: 58.

Notes: Newly restored from synonymy in *A. agrestis* by Blakemore (2005) as per Sims & Easton (1972) and Easton (1981).

Distribution: From northern Japan; doubtfully in USA if we read Gates correctly.

Diagnosis: Spermathecae paired in 5/6/7/8; markings as large, closely paired presetal sucker-like discs median to male pores on 18 that lack glands internally; and closely paired 'dark patches' claimed on 7 too (obviously artefactual due to the result of copulation – RJB pers. obs).

Remarks: Male pores in slight copulatory pouches in tyes specimens of *Metaphire hataii* [as described in 2 out of 248 specimens (of *P. agrestis*) by Kobayshi (1938: 142, 145)] qualify this taxon for inclusion in *Metaphire* separate from *Amynthas*. Gates (1958: 3) said that *P. hataii* specimens lacking male pores and with a pair of presetal genital markings on 18 could be distinguished from *agrestis* only by absence of brown patches on 8 (or 7?). Cf. *A. gomejimensis*.

Metaphire servina (Hatai & Ohfuchi, 1937)

Pheretima servinus (sic) Hatai & Ohfuchi, 1937: 1, figs. 1-2. [From many localities in Miyagi-ken and Aomori-ken in NE Honshu. Types not known].

Metaphire servina : Sims & Easton, 1972: 238 (*Metaphire glandularis* species-group);

Easton, 1981: 59 (but he mistakes the spermathecae as in 6/7/8/9); Blakemore, 2003; 2005; 2006; 2007; 2010 (corrected location of spermathecae in 6/7/8).

Distribution: Japan, (mainly northern Honshu).

Diagnosis: Spermathecal pores in 6/7/8. Male pores within small copulatory pouches unusually displaced posteriorly on 18. Genital markings as smaller discs within larger glandular masses that encompass male pores, paired median to male pores equatorially on 18 (numerous capsulogenous glands or large glandular masses correspond internally). Intestinal caeca manicate. Body usually less than 120 mm.

Remarks: Easton (1981) mistakenly has *Metaphire servina* with three pairs of spermathecae in 6/7/8/9 while Sims & Easton (1972) place it in a group with only two pairs in 6/7/8 as in the original description. Ohfuchi (1937: 19) stated that his proposed *Pheretima hataii* resembled *Pheretima servinus* except for its three pairs of spermathecae as did his *P. gomejimensis* except for its lack of genital markings on 18. It is thus possible that these taxa are closely related and that *P. gomejimensis* is synonymous with *M. servina*. Two other taxa that are possibly related are *A. tappensis* and *A. vittatus*, the latter having nomenclatural priority. This taxon is a recently new combination in the *M. hilgendorfi* group.

Amynthas*? *gomejimensis (Ohfuchi, 1937)

Pheretima gomejimensis Ohfuchi, 1937a: 18. [From Oshima and Gomejima (Aomori-ken). Types?].

Amynthas gomejimensis : Sims & Easton, 1972: 237 (*tokioensis*-group); Easton, 1981: 52; Ishizuka, 1999a: 59 (misspelled "gomejimaensis"); Blakemore, 2003; 2005; 2007.

Distribution: From Japan.

Remarks: Stated by Ohfuchi (1937: 19, 24) to resemble *Pheretima servinus* (= *Metaphire servina*) or his own *P. hataii* (?= *Metaphire hataii* cf. *A. agrestis*) in all characters except for its lack of genital markings on 18; thus, because no fully mature specimens were found, the relationship is most likely with either of these two (or three) previous taxa. More mature specimens may change shape of male pores and develop genital markings.

Amynthas koreanus (Kobayashi, 1938)

Fig.2.2.8a, *P. koreana* Kobayashi, 1938: 115, fig. 5; Fig. 2.2.8b synonym *P. conjugata*.

Pheretima koreana Kobayashi, 1938: 115, fig. 5. [Korea. About a dozen specimens, types lost?].

Amynthas koreanus: Sims & Easton, 1972: 236 (*A. morrisi*- group); Blakemore, 2003: 43, addenda; 2005; 2007 (syn. *conjugata*).

Pheretima conjugata Ishizuka, 1999b: 34, figs. 1-8. [Japan. A dozen specimens in Tokyo museum].

Distribution: Japan/Korea.

Diagnosis: Variously described as either having paired or unilateral spermathecal pores in 6/7 or 5/6 with deformed spermathecae, or lacking them completely, and often lacking genital markings and male pores; size 90-140 mm.

Remarks: In neither of the above cases is the condition in the holotype explicitly stated, but irrespectively these names may be 'grab bags' of degraded morphs of more than one unresolved species with no particular biogeographic nor phylogenetic merit. Their manicate caeca probably place them in one or more parts of the *Metaphire hilgendorfi* species-complex: most likely associated with *Pheretima irregularis*, from which neither Kobayashi (1938) nor Ishizuka (1999b) managed to adequately differentiate them, or possibly to the ambiguous *A. ambiguus* (Cognetti, 1906). There is almost no difference in the degraded specimens that Ishizuka (2000) unnecessarily provided a name for from those described earlier by Kobayashi (1938), showing that little new has been learned during the last 60 years.

In this most recent revision it seems to me that these taxa (*koreana*, *conjugata*) are the same as *P. schizopora* (Goto & Hatai, 1898:76), especially since the justification for their original name was for a pair of female pores and Ishizuka (1999b: fig. 8) appears to show separate pores for his *P. conjugata* (not that this is a reliable taxonomic character) and, moreover, that this latter taxon is probably synonymous with *A. tokioensis* (Beddard, 1892), into which all these names should probably be sunk.

Metaphire soulensis (Kobayashi, 1938)

Fig. 2.2.9a, *Pheretima soulensis* Kobayashi, 1938: 131, fig. 8 with male pores in pouches and extruded same as Fig. 2.2.9b, *P. aokii* Holotype; Fig. 2.2.9c, *P. shikiensis* same as Fig. 2.2.9d, *P. aokii* paratype; Fig. 2.2.9e, *P. aokii* legend unedited online *sans* copyright here. Fig. 2.2.9f NMST An 421 specimen from Mishima.

Pheretima soulensis Kobayashi, 1938: 131, fig. 8. [From Keiki-dō, Keijo (now = Seoul, Kyonggi-do), South Korea. Ten specimens. Types unknown?].

Pheretima shinkeiensis Kobayashi, 1938: 134, fig. 9. [A specimen from Kokai-do now

in SW North Korea].

Pheretima soulensis : Kobayashi, 1941a: 51, 53; 1941b: 260 (widespread in Japan).

Metaphire soulensis : Sims & Easton, 1972: 238 (*Metaphire glandularis* - group); Blakemore, 2003a: 43 (syns. *Pheretima shinkeiensis* Kobayashi, 1938**,** *Pheretima aokii* Ishizuka, 1999; held as *species incertae sedis*); 2003: 43, addenda; 2005; 2007 (syns. *shinkeiensis, aokii*).

Pheretima aokii Ishizuka, 1999b: 36, figs. 9-18; Ishizuka *et al.*, 2000b: 180. [From around Tokyo, including the Imperial Palace and, incredibly/magically without any explanation or justification whatsoever, from Korea!! Types in Tokyo]; Minamiya *et al.* 2007; 2009 (www.eec.miyakyo-u.ac.jp/meme/data/kiyou10/07.pdf and http://www7.ocn.ne.jp/~izunuma/down/Izunuma_03_02.pdf and Ito *et al.*, 2011 (www.ffpri.affrc.go.jp/pubs/bulletin/421/documents/421-5.pdf) [where there is rather childish attempts with "Japanese science" to resurrect something variously called either "*Pheretima aokii* Ishizuka, 1999" or "*P. aokii* (Ishizuka, 1999)" completely ignoring 70 years of taxonomic progress in real Science! This taxon in now invalid due to ICZN (1999: Art. 11.4)].

Amynthas dageletensis Hong & Kim 2005: 129. [From Korea].

Amynthas chiakensis Hong & James, 2013: 76. [From Korea].

Material examined: NMST An 421 two mature specimens (one sketeched and dissected) from Shirotaki-koen at Mishima, Shizuoka-ken, collected 7th VI 2010 by RJB and Yuko Hiramoto. Specimens have also been found at Kuzuharagaoka Shrine, Kamakura, Japan (several specimens collected 13.vi.2004 by RJB, Amanda Reid and Yuko Hiramoto and in YNU collection) that agree superfically although they lack male pores and markings, but have an extra pair of spermathecae in 5/6 (cf. the smaller *A. kamakurensis*). Other speciemens are in Blakemore *et al*. (2015).

Distribution: Korea and Japan and ?China [for *yamadai*, Easton (1981: 60) states "*Japan, China, Korea*", but China is probably just from Kobayashi (1939) who claims *yamadai* in Japan and China]. Kobayashi (1941a, b) had described it as widely distributed in Japan as well as in Korea.

Diagnosis: Parthenogenetically degraded morphs 50-125 mm long described with adiverticulate spermathecae in 6/7/8 (sometimes lacking?), and (always?) lacking prostate glands and male pores but with genital markings as clusters of two or more papillae on 18 that have corresponding glands internally in the usual position of the male

pores. These papillae, when fully formed, are at least partly retractable into the body (hence possibly qualifying for inclusion in *Metaphire*). Intestinal caeca manicate in 27.

Remarks: Easton's (1981: 60) synonymy of *M. soulensis* (Kobayashi, 1938) in *M. yamadai* (Hatai, 1930), misspelt "yamardai", is not accepted here due to differences in markings around the male pores and other characters, as described on a neotype by Blakemore (2012).

Specimens with or without copulatory pouches are included because an almost continuous series may be thus found: from degraded morphs that only have a few superficial markings on 18 [for example, male sterile morphs such as *Amynthas shinkeiensis* (Kobayashi, 1938) sensu Sims & Easton (1972: 245)], to those with many markings on an invaginated disc on 18 [for example, male sterile morphs such as *Metaphire soulensis* (Kobayashi, 1938) sensu Sims & Easton (1972: 238)]. Kobayashi's (1938: fig. 8) of *P. soulensis* is essentially the same as Ishizuka's (2000e: figs. 9-16) of the holotype of *P. aokii*, and Kobayashi' (1938: fig 9) of *P. shikeiensis* is again similar to Ishizuka's (2000e: figs. 17-18) of a paratype of *P. aokii*. In Ishizuka *et al*. (2000b: 180) the distribution of *P. aokii* is claimed to include Korea, but this is without obvious justification although, by applying the Principle of Priority, as it now appears synonymous with *M. soulensis* then the range of this latter taxon is extended to Japan. In actuality, the biogeographic value of these parthenogenetic events is often open to discussion. This taxon in now invalid due to ICZN (1999: Art. 11.4).

Amynthas dageletensis Hong & Kim 2005: 129 was an unnecessary name from Ulleungdo Island, Korea for a degraded parthenogenetic morph that appears to be in synonymy of *M. soulensis* after Blakemore (2013b), although previously thought just about any other member of the *M. hilgendorfi* / *A. tokioensis* group. *Amynthas chiakensis* Hong & James, 2013 has DNA that agrees with the Mishima and Dagelet specimens of Blakemore (2015) and other Genbank *A. soulensis* specimens.

[*Amynthas gucheonensis* (Song & Paik, 1970) (cf. *A. tokioensis*; *A. vittatus*)

Pheretima gucheonensis Song & Paik, 1970: 103, figs. 24-35. [From Geoje Island, South Korea. Types?].

Amynthas gucheonensis : Sims & Easton, 1972; Easton, 1979: 119; 1981: 52.

Distribution: Korea.

Diagnosis (from original and translated website here): Length up to 147 mm. Setae 54-82. Male pores superficial on ventro-lateral circular-shaped disc. Paired genital

marking patches are present in the neighborhood of the male pores medially and anteriorly close to the setal line of 18. Spermathecal pores in 6/7 and 7/8, each on a minute tubercle and with few glands plus, below each on 7 & 8, are rows of 3-10 tubules (as in *vittatus*). Intestinal caeca manicate.

Remarks: Belonging to the *Amynthas tokioensis* group as stated by Easton ((1979: 119; 1981), this could be another synonym of *A. tokioensis*, or more likely due to its more extensive GMs, of *A. vittatus*. Song & Paik (1970: 107) compare their species to *A. tappensis*].

[***Amynthas jiriensis*** (Song & Paik, 1971) – see *A. tokioensis*].

[Space, time and funding considerations preclude addition of the remainder of all dozen or so later Korean taxa with manicate caeca recently proposed by Hong & James (2001), Hong & Lee (2001) and Hong & Kim (2005), etc., names as noted above].

Amynthas purpuratus (Ishizuka, 1999b).

Pheretima purpurata Ishizuka, 1999b: 42 [misspelt "*purpuratga*" by Ishizuka (2001: 14)], [non *Perichaeta purpurea* Benham, 1897 (= *Amynthas purpureus*)].

Remarks: The description is confused regarding the distribution of anterior genital markings, and it is probable that this species is similar to *Amynthas tappensis* (Ohfuchi, 1935) and therefore in synonymy of *A. vittatus*, but this needs confirmation from inspection of types. This nominal taxon is now considered invalid.

[?***Amynthas ? dageletensis*** Hong & Kim, 2005

?*Pheretima hilgendorfi* : Song & Paik, 1969 (specimen lacking male pores or some other *Pheretima* morph from Dagelet Island by these prior authors).

Amynthas dageletensis Hong, Y. & Kim, Tae-Heung 2005: 129 plus figures of missing spermathecal and male pores. [From Ulleungdo Isl., Korea; types in some Korean Uni.]; Blakemore, 2005; 2007 (listed, with some justification, as ***species inquirenda***).

Remarks: Described thusly: "Amynthas dageletensis *sp. nov. lacks spermathecal pore, spermathecae, prostates, and male pore. These characteristics are systematically important and unique to the species among Korean members of* Amynthas". Genital markings are a series of papillae on either side on 18. This 'tube', unnecessarily provided with a name, has manicate caeca thus qualifying for membership of the long

trash-can list of *M. hilgendorfi*/ *A. tokioensis* synonymic names (see also *Metaphire soulensis*). Molecular 'resolution' is irrelevant unless compared against types of all of the prior group names erected from 117 years ago from Japan and Korea, or elsewhere].

[**End of *M. hilgendorfi* / *A. tokioensis* spp.complex group** – Start is here].

Metaphire houlleti (Perrier, 1872) **species-complex** s. Blakemore, 2008

Pheretima houlleti s. Gates, 1972.

Metaphire houlleti is thought to comprise dozens of different parthenogenetic morphs distinguishable by somatic and genital characters with its number of spermathecae ranging from three pairs in 6/7/8/9 to fewer in various athecal morphs (Gates, 1972).

Metaphire houlleti (Perrier, 1872)

Fig. 2.19a *Perichaeta houlleti* Perrier (1872: figs. 31-63) also here and here.

?Fig. 2.19b *M. houlleti* from NE Thailand deposited by RJB in Tokyo (NSMT An 425).

Fig. 2.19c *M. houlleti* lower lhs sketch superimposed on Easton (1982: fig. 4) pheretimoids.

Fig. 2.19d online sketch of *M. houlleti* from Shen *et al.* (2005: fig. 2).

?Fig. 2.19e, f, g, h *M. houlleti* Penalosa Negros specimen from PI (RJB 2014).

Perichaeta sp. Perrier, 1871: 278.

Perichaeta houlleti Perrier, 1872: 99, figs. 31-63. [Type locality Calcutta collected by M. Houllet in 1871. Types in Paris Museum (AE653?, 654) two tubes examined by Gates (1927: 228) who enigmatically said that one tube contained a specimen with penial setae differing in no detail from those of *Megascolex mauritii*; while the other four specimens were much softened, stretched or broken but only one, the lectotype, was dissected and none appeared to have penial setae. Types classed as smaller Hp morphs by Gates (1972: 194)]. Beddard, 1887: 389; Horst, 1892 (syn. *campanulata*), 1893: 64; Beddard 1893, 1895; Michaelsen, 1897: 234.

Megascolex houlletii: Vaillant, 1889: 75.

Perichaeta campanulata Rosa, 1890: 115, t. 1, figs. 9-10. [Type locality Palon, Pegu, Myanmar. Types in Genoa Museum, two worms contained in a tube with Cat. N. 47 were examined by Gates (1927: 227) who said it was the same as his *tortuosa*

he later also folded into *houlleti*. Classed as the H morph by Gates (1972: 191) including all worms with trilobed penial bodies and with penial setae].

Perichaeta udekemi Michaelsen, 1892: 240, t. 13, fig. 17 (of spermatheca). [Sometimes mistakenly as "1890", Michaelsen originally cited his species as "*Grube (in litteris)*". From Java, Leiden No. 1464, types lost possibly after Berlin transfer?].

?*Perichaeta guillelmi* Michaelsen, 1895: 32, fig. 7. [From Wuchang in Hupei province, China. Types in London, Hamburg and Turin]. [Some authors (e.g. Chen, 1933, 1959; Gates, 1935, 1935; Shen *et al.*, 2005) maintained *guillelmi* separately from *houlleti* – see notes below; but Chen (1933: 249, 1959: 7) also thought *P. vulgaris* (Chen, 1930) was synonymous with *guillelmi* which is, at least, morphologically close to *houlleti*; and Chen (1959: 8) compared it to *tschliensis*].

Pheretima crescentica Fedarb, 1898: 447. [From NW India. Types in British Museum].

Amyntas houlleti: Michaelsen, 1899: 12; Beddard, 1900: 613 (part.).

Pheretima houlleti: Michaelsen, 1900: 273 (syn. *campanulata*, *udekemi*, *guillelmi*); Stephenson, 1923: 304 (syn. *campanulata, crescentica*); Gates, 1927: 227 (separating *campanulata* = *houlleti tortuosa*); Stephenson, 1932a: 45 [questioning Gates' (1927) separation off of *campanulata*, cf. Gates' (1972: 190-195) extensive review again including them in synonymy]; Stephenson, 1932b: 216 (syn. *kelantanensis*); Gates, 1958: 16; 1972: 190-195 (syn. *wimberleyana*, *tortuosa*, *rugosa*, *campanulata campanulata*, *campanulata penetralis*, *campanulata meridiana, ?yapensis*); 1982: 52 (syn. *meridiana*).

Amyntas kelantanensis Beddard, 1900: 902. [From Aring, Kelantan State, Malaysia. Syntypes in British Museum BM:1924:3.1.220/230 inspected by Stephenson (1932) and Sims & Easton (1972: 180) who included it in their extensive yet unresolved *M. houlleti* group].

Pheretima wimberleyana Stephenson, 1925: 62. [Type locality Wimberleyganj, Andamans. Types in Indian Museum. [An H morph (Gates, 1972: 191). Name misspelt "wimberlayana" by Sims & Easton, 1972: 246 and Reynolds & Cook, 1976: 190].

Pheretima houlleti var. *tortuosa* Gates, 1926a: 157. [Locality Rangoon. Types none]. [An H morph by Gates, 1972]. Gates, 1926b: 454.

Pheretima houlleti var. *rugosa* Gates, 1926a: 157; 1926b: 459; 1930: 311. [Locality Rangoon. Types none]. [Classed as A morph synonym by Gates, 1972: 193; name sometimes misspelt "*houletti rugosa*". Note: James' Philippine *Pheretima*

rugosa homonym replaced with ***Pheretima asurgo*** Blakemore, 2006].

Pheretima rugosa : Gates, 1932: 398 [non *Pheretima rugosa* James, 2004: 300 (= *Pheretima asurgo* Blakemore, 2006 nom. nov.)].

?*Pheretima vulgaris vulgaris* Chen, 1930: 12 from Kiangsu, China.

?*Pheretima vulgaris agricola* Chen, 1930: 18 from Nanking, China.

?*Pheretima ichangensis* Fang, 1933: 180 [misspelt "inchangensis" by Sims & Easton (1972: 238)].

Pheretima campanulata var. *penetralis* Gates, 1931: 435. [Indian types lost, H morph by Gates, 1972].

Pheretima campanulata var. *meridiana* Gates, 1932: 457; Gates, 1937: 358. [Locality Myittha. Types none. Larger Hp morph by Gates, 1972].

?Pheretima yapensis Ohfuchi, 1941: 283. [From Yap. Types?].

Metaphire houlleti houlleti: Sims & Easton, 1972b: 238 (*houlleti*-group).

Metaphire houletti (lapsus pro *houlleti*): Easton 1982: 731; 1983: 121, tab. 1, 128.

Metaphire houlleti : Blakemore, 2002, 2004, 2005, 2008, 2010, 2012; Shen *et al.*, 2005: 13, fig. 2; Blakemore, 2016: fig. 4.

Amynthas huangi James *et al.* 2005: 1014, fig. 2E,F (on p. 1010) [From Taiwan. Monotype NMNS 4054-011]. [In synonymy from Tsai *et al.*, 2006 and Chen *et al.*, 2008; Blakemore *et al.* 2006; Blakemore, 2008, 2010; Chang *et al.* 2009, and as was already notified to the author's in the prior MS referee report by the current author dated 8th Jan., 2004 as shown in Blakemore (2004 and online here: http://opuscula.elte.hu/PDF/Tomus41_2/Blakemore_App2.pdf). It is especially surprising therefore that James *et al.* (2005) attempted to claim a new record of *M. houlleti* in Taiwan when they completely misidentify *A. huangi* that is its junior synonym! – this subsequently compounded by their weaselly attempts to justify their numerous errors by claiming that everyone else is wrong. E.g., with almost complete arrogance enveloped entirely in ignorance, Wang & Shih (2010: 65) claim that: "*A. huangi... can easily be distinguished from ...* ***M. houletii*** [sic!!] (*S.W. James pers. com.)*", and in a sell-out, Chang *et al.* (2009) say: "*This dispute is probably a matter of opinion on morphological variations, with solution relying on new data in the future (S. James, personal communication).*" What about distinguishing it from all the various, previously named 14 synonyms of *M. houlleti* too? Or would that take too great a deal of basic knowledge and too much effort and hard work? As all the

other authors – this one included – have already explained, cogently and repeatedly, how *A. huangi* is in *Metaphire* and how it is, moreover, yet another name irresponsibly added to the list of junior synonym of *M. houlleti* [with or without its correct spelling]. Yes, how much easier it is to just claim the glory of a new species name and "*leave it up to others to sort out*" (S.W. James public comm. April, 2011 IOTM5 meeting). See also the *M. monsoonus* debacle].

Taxonomic Notes: Sims & Easton's 1972 retrograde *houlleti*-group has >40 spp. Name often also misspelt "*houlletti*" or "*houletti*". Gates (1927) redescribed the types (poorly?), and Gates (1972: 190-195) gives exhaustive descriptions and comprehensive synonymies of the variously degraded parthenogenetic morphs attributed to this taxon (including unnamed intermediate and rare ARZ morphs). All the above synonymies, mostly from Gates (1972), listed separately in Sims & Easton (1972) who merely catalogue species' synonyms without comment, presumably leaving it up to us to determine affinities at some later date.

Pheretima vulgaris (and *P. vulgaris agricola* both) by Chen (1930) were thought synonyms of *P. guillelmi* (an erstwhile synonym of *P. houlleti*) by Chen (1933: 249, 1959: 7). ***Metaphire guillelmi*** and the similar species, ***Metaphire virgo*** with its prostate glands (and spermathecae) reduced, are both briefly described under **Remarks** below.

Pheretima houlleti bienryoana Ohfuchi, 1956: 169 from Okinawa was placed in synonymy of *Amynthas flavescens* (Goto & Hatai, 1898) by Easton (1981: 50).

Definitive resolution of *M. houlleti* requires DNA analysis of Kolkata topotypes.

Diagnosis: *Metaphire* with spermathecal pores (sometimes some lacking) usually paired in 6/7/8/9 about 0.3-0.5 C apart. Genital markings, when present, very small near spermathecal pores and/or inside copulatory pouches on 18 (both sets associated with GM glands). Spermathecae, when present, each with a tortuous (zig-zagging) diverticulum (often compressed) usually having accessory gland (one or more) accompaniments above and/or below (Perrier, 1872: fig. 37, 59). Penial setae may be present or absent (species-complex). Male pores in copulatory pouches with largish (C-shaped?) or rounded openings. Intestinal caeca simple from 27.

Distribution: Indigenous to Myanmar and southeast Asia; occasional allochthonous records around the world in tropical lowlands: e.g., India, Bangladesh, Sumatra, Myanmar, China, Taiwan (e.g. by Shen *et al.*, 2005), Thailand, Malaysia (e.g. Kuala Lumpur), Singapore, Vietnam, Laos, Cambodia, Philippines (e.g., Manila by Beddard,

1886; Negros by RJB), Bahamas, Nepal (e.g. as *Pheretima campanulata* by Sims, 1963: 84), Sri Lanka, Indonesia, Fiji, ?Yap, Belice, El Salvador, Cuba (Gates, 1958), Mexico, Bahamas (Fragoso, pers. comm.), Sierra Leone, Madagascar, France (e.g. from Darwin's 1881: 106 report thought partly responsible along with *P. affinis* and *P. luzonica* for casts found at Nice), French Guiana, Guadeloupe (Csuzdi pers. com. and Csuzdi & Pavlicek, 2009), USA, Papua New Guinea, and from Australia (Easton, 1982): at Cooktown, northern Qld. also beside Manton River 66 Km S of Darwin, NT (see Blakemore 2016). The map in Blakemore (2016: fig. 10) has a questionable record from Ryukyus (Okinawa) for the *P. houlleti bidenryoana* Ohfuchi, 1956 report that was later put in synonymy of *Amynthas flavescens* (Goto & Hatai, 1898). However, a recent taxon from northern Okinawa, *M. glauca* (Azama & Ishizuka, 2018) **n. comb**. Blakemore (2020), mostly complies with *M. houlleti* species-complex adding Ryukyus to its range.

Material examined: NT specimens in Author's Australian collection; plus Thai specimen collected by Johnny Boyer of CIRAD in Oct. 2009, in Tokyo: NMST An 425. Hacienda Remedios organic canefield, RJB, 29/1/14 one specimen (l = 95, red-brown dorsum, 1st DP 10/11, sp 6/7/8/9 lateral, male pore C-shaped, sp with appendage, simple caeca) (see Blakemore 2016).

Habitat: In gardens, bamboo groves and forests, in rotting logs, mud, compost (in Indore). A lowland tropical species according to Gates (1972).

Behaviour: Activity possible throughout the year with sufficient moisture.

Length: 40-240 (usually around 100-160) mm.

Width: 3-7 mm.

Segments: 86-200.

Colour: Dark reddish-brown or grey in dorsum (often lacking in setal strips).

Prostomium: Open epilobous.

First dorsal pore: Often in 11/12 or 9/10 (10/11 in PI specimen noted above), sometimes in 7/8-12/13; Gates (1927: 229) has "9/10 (8/9)" possibly for the types, and "11/12" for his *tortuosa*. Such variation is unusual.

Setae: Numerous (ca. 20-60). Penial setae may be present as five or fewer ornamented setae in wall of copulatory chamber (Gates, 1927).

Nephropores: ?

Clitellum: Annular 14-16.

Male pores: On 18 in lateral slits of copulatory pouches ca. 0.3 circumference apart, 10-12 setae often intervene (sometimes with one to three penial setae and genital marking

glands present internally).

Female pore: Midventral on 14.

Spermathecal pores: Three pairs in 6/7/8/9 with wide openings ca. 0.3-0.5 circumference apart; fewer in parthenogenetic morphs (sometimes absent).

Genital markings: When present, near (inside) spermathecal pores and/or inside copulatory pouches (with one or more small stalked genital glands internally). Gates (1927) has a single stalked gland associated with each spermathecal pore for typical forms, or "*usually 2-5*" for his *tortuosa* synonym.

Septa: 8/9/10 aborted, 5/6-7/8 thickened.

Dorsal blood vessel: Single.

Hearts: 10-13.

Gizzard: Large in 8.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): In 15; caeca simple in 27-22; typhlosole present.

Nephridia: Meroic.

Male organs: Testes/funnels in 10 and 11 in sacs; seminal vesicles in 11 and 12 (sometimes reduced).

Ovaries: In 13.

Prostates: Racemose (with three main lobes) in 16,17-20,21, ducts long to eversible copulatory chambers that may have small stalked secretory glands externally (in 18 or also in both 17 and 19) and a penial structure internally with the primary male pore. These chambers were reduced in *P. kelantanensis* but a "*white glandular cushion*" was present according to Stephenson (1932: 218).

Spermathecae: Small in 7, 8 and 9, duct shorter to ampulla and diverticulum entally that has slender looped stalk (enveloped in conective tissue) and ovoid seminal chamber; small accessory glands present on (or near) duct above and below each diverticulum. Often one or more spermathecae may be deleted/deformed.

Gut contents: Organic matter in in Thailand specimen.

DNA: COI barcode specimens comply morphologically from keys, however, are two different taxa, neither of which may be actual be *M. houlleti* – as already noted, likely resolution is only from topotype DNA that complies morphologically with Paris type.

>JET031-10 [*Metaphire houlleti* Thailand 1/1/2009] [NSMTAn425] COI partial

NNNN

ACNGATCAACTATATAATACAATTGTNNN

ACCCTATACTTTATTTTAGGAATTTGAGCCGGAATGATCGGGACCGGAATAAG
ACTTCTTATTCGAATTGAACTAAGACAACCTGGATCATTTTTAGGCAGAGACC
AACTATACAACACAATTGTAACGGCACACGCATTTTTAATAATTTTCTTTTTAG
TTATACCAGTGTTTATTGGTGGATTTGGAAATTGACTACTACCCCTTATATTAG
GAGCTCCCGACATAGCATTCCCCCGCCTCAACAACATAAGATTTTGACTACTC
CCACCATCACTAATCCTATTAGTATCATCTGCTGCTGTAGAAAAGGGAGCGGG
TACTGGATGAACACTATACCCCCCGCTGGCTAGAAACATTGCCCATGCGGGG
CCATCAGTAGATCTAGCCATTTTCTCACTACACCTGGCAGGAGCTTCCTCAAT
TCTAGGTGCAATTAACTTCATTACCACAGTAATTAATATGCGATGAACAGGAC
TACGACTAGAACGAATTCCTCTATTTGTATGGGCAGTAGCAATTACTGTCGTA
TTATTACTTCTATCACTCCCAGTATTAGCAGGAGCAATTACAATACTACTAACA
GATCGAAATTTAAACACATCATTCTTTGACCCCGCTGGGGGAGGTGAT

Blast – in 2017 agrees 100% with *M. houlleti* from Vietnam (MF481209); "*Metaphire sp*" from Thailand (KU565295); *M. holleti* from India (not Indore?) (KX832074-6). BLAST of JET-147 vs. Pe9 Identities = 511/632 (81%), i.e., different taxa, confirming it as a molecular species complex (see Blakemore 2011, 2012a, 2016 for details)! In 2020, as well as the Vietnamese matches, were 100% for MF479445 "*Metaphire hijauensis*" Ng & Panha, 2018 from Thailand and MH845488 "*Metaphire bannaensis*" Qiu & Jiang, 2016 from China... from this Ref.

Thus the conclusion is that this taxon differs from *M. houlleti* proper (but may have been mutually confused in some or several past reports) and, if these DNA IDs are to be trusted, then the priority may go to *M bannaensis* with synonym *M. hijauensis* and this taxon has its distribution in SW China, Thailand and Philippines (this latter a new record by the current author). Confirmation of the true identity will be left to the ship of fools who have driven us further into chaos by their egos and bad taxon navigation].

Other Remarks on *M. houlleti*: Northern Territory, Thai and Negros P.I. specimens inspected; the above description also extracted from original accounts and those subsequently by Michaelsen, Stephenson and Gates. It was also found in compost at Indore MP India, the site of Sir Alfred Howard's organic farming research station along with *Lennogaster pusillus, Amynthas alexandri* and *Eudrilus eugeniae* (RJB pers. obs. March, 2016) (Ref.). This is obviously a species complex in need of urgent remedy.

Some other species also have accessory glands on or near spermathecae, e.g. *A. aspergillum* (Perrier, 1872) and some Sumatran specimens of Horst's (1883: 186)

Megascolex indicus (= *Amynthas corticis*), although these latter may possibly have been parasitic artefacts. Species with large eversible male organs that resemble *Duplodicodrilus schmardae* are further characterized by manicate intestinal caeca. Species with secretory diverticula adjacent to the non-superficial (and eversible) male pores are attributed to monotypic genus *Manus* Blakemore, 2010 for *M. koellikeri* (Michaelsen, 1928) from Japan that is further similar in its penial setae, yet its intestinal caeca are also manicate. The relationship of *M. houlleti* to these taxa may require re-evauation.

Metaphire guillelmi (Michaelsen, 1895) from Hupei, China (syns. *P. vulgaris* Chen, 1930; *P. v. agricola* Chen, 1930; ?*P. ichangensis* Fang, 1933) was held *incerae sedis* by Blakemore (2007, 2008), but is at least a member of the *M. houlleti* spp-group. Michaelsen (1897, 1900, 1931) and Gates (1935: 10) concluded it was probably a variety of *M. houlleti* whereas Chen (1933: 249, 1959: 7, fig. 6) maintained it separately on the ground that its spermathecal pores were invaginated and that arrangements of male pores differed. These synonyms also implicated are, in summary: *Metaphire vulgaris vulgaris* (Chen, 1930: 12) from Kiangsu, *M. v. agricola* (Chen, 1930: 18) from Nanking and *Pheretima ichangensis* Fang, 1933 that was though a synonym of *M. gullelmi* by Gates (1948: 10). Note: many Chinese papers miscite this taxon as "***Pheretima guillemi***" and claim this is widely used in vermiculture which puts the correct identity of their species used in doubt.

Metaphire virgo (Beddard, 1900: 895) was said by Gates (1972: 153, 224) to be the closest species to *M. houlleti* but that possibly differed primarily by lack of glands associated with its spermathecae. It is diagnosed separately below based on redescriptions by Stephenson (1932: 236) and Gates (1972: 222) who has these synonyms: *P. mamillana* Gates, 1931; *P. mendosa* Gates, 1932; and ?*A. perichaeta* Beddard, 1900: 896 – this latter mainly differing in its more developed prostates and spermathecae with long, much coiled, diverticula; its hearts were said to be in 13 by Beddard, or 12 by Stephenson (1932: 228).

Diagnosis of ***Metaphire virgo*** (Beddard, 1900: 895) as originally and re-described by Stephenson (1932: 236) from Beddard's two types and by Gates (1960: 275)who said there were originally seven specimens [as *Amyntas virgo* in Cambridge and in BMNH 1904:10:5:197, 1924:3:1:211-3 (these not found on shelf pers. obs. RJB VI.2013) with prostates small or absent and spermathecae vestigial – indicative of immaturity?]; and again by Gates (1972: 222) who included in its synonymy both *P. mamillana* Gates,

1931: 400 and *P. mendosa* Gates, 1931: 400 [and, possibly *A. perichaeta* Beddard, 1900 (type BMNH 1924:3:1:231 - this not found on shelf pers. obs. RJB VI.2013), although Stephenson (1932: 227) had provisionally maintained it separately, as here].

External characters: Biometry: (152, Beddard; 51-210, Gates), most usually 152-210 by 2-7 mm with 97-157 segments and ca. 20-56 setae per segment. Prostomium epilobous. Colour reddish or brownish slate. First dorsal pore from 11/12 (Stephenson), 12/13 (Gates). Male pores in copulatory pouches with puckered lips ca. 0.3 circumference apart. Spermathecal pores lateral in 6/7/8/9. Genital markings only present within copulatory chambers.

Internal morphology: Septa (8/9),9/10 aborted. Gizzard as usual. Caeca simple in 27-25 (Stephenson), 27-17 (Gates). Last hearts in 13. Holandric: seminal vesicles in 11 & 12 with pseudovesicles in 13,14. Ovisacs in 14. Prostates often reduced but copulatory pouches remain. Spermathecae often reduced and "*extremely small*"; when more developed with a zig-zag diverticulum (accessory glands as described for *M. houlleti* not reported).

Distribution: Thailand, Songkhla State or in its correct Malay form, as used by Beddard and Stephenson, "*Singgora*" = City of Lions (from paddy-fields at Tale), Myanmar, Malaysia (Perlis and Kedah). Gates (1972: 223) said: "*Perhaps man was responsible for getting* P. virgo *across the Salwee*n" (= Nu Jiang River).

Notes: Parasites often heavy in parthenogenetic morphs (Gates, 1972: 223); yellowish masses on nerve cord & nematodes in spermathecae (Stephenson, 1932: 239, fig. 11).

It seems that *Metaphire virgo* is close to, but perhaps a separate taxon from, both *M. houlleti* and possibly the Malaysian *M. perichaeta* (for which Beddard had mistaken the original location of spermathecae in 6-8, rather than 7-9 as found by Stephenson, 1932) that differs in its slender spermathecal diverticulum that is a "*coiled mass*.." "*..in a ball of closely compacted loops*". However, Gates (1972: 222) accepted that *M. virgo* also comprises several parthenogenetic morphs.

Metaphire javanica (Kinberg, 1867)

[Cf. ***M. californica***].

Rhodopis javanica Kinberg 1867: 102. [Type locality Tjibodas, Java. Types in Stockholm Museum: 1946; inspected by Sims & Easton (1972: 216)].

Megascolex sumatranus Horst, 1883: 189. [From Lebong, Sumatra; Type in Leiden

Museum: 1839; inspected by Sims & Easton (1972: 216) under *M. javanica*]. Length 70 mm, segments 94. Note: it is obvious that Horst miscounted the anterior segments when he said that "tubular spirally wound glands on the anterior side of the 6th and 7th septum. The muscular stomach is situated in the 9th and 10th segment" as nephridial forests or peptonephridia are usually in 4, 5 & 6 with the gizzard is in 8-9. Thus when he described the spermathecae (what he called "copulatory pouches") in 7th and 8th segments, they were most likely in 8 & 9. [Non *sumatrana* : Beddard, 1892a: 155, Pl IX, fig. 4 (= *M. californica*). Note: Beddard thought that *Perichaeta sumatrana*: Horst (1885: 5, figs. 2a,b) from Buitenzorg, Java was perhaps misdiagnosed as the spermathecae were stated to be one segment further back].

Pheretima capensis var. *sumatrana* : Michaelsen, 1900: 260.

?[*Megascolex capensis* Horst, 1883: 195. [From Cape of Good Hope; Type in Leiden Museum: 1890; also found at Timor by Horst (1893: 322)]. Cf. *quadragenaria*].

Perichaeta javanica: Beddard, 1891: 76.

?[*Perichaeta operculata* Rosa 1891: 398, fig. 6. [From Java. Types in Vienna?]].

?[*Perichaeta inflata* Horst, 1893: 327, pl. X, fig. 8. [From Tjibodas, Java; Type in Leiden Museum: 1889; inspected by Sims & Easton (1972: 216). Note: its small size (55 mm) and particularly long and coiled diverticulum shown in Horst's (1893: fig. 8) possibly suggests a separate taxon].

Pheretima inflata : Michaelsen, 1916: 13 (syn. *parva, capensis* [part.]*, capensis inflata*)].

?[*Perichaeta tenkatei* Horst, 1893: 321. [Type in Leiden Museum: 1891]].

?[*Perichaeta tjibodae* Horst, 1893: 326. [From Tjibodas (Java). Types in Leiden?]].

?[*Perichaeta parva* Ude, 1893: 64. [Type in Berlin 7109, missing]].

?[*Perichaeta sexta* Benham 1895. [Type in Oxford 1583]].

?[*Pheretima capensis* (= ?*Rhodopis javanica*): Michaelsen, 1900: 259-260 (syn. ?*javanica* Kinberg, 1867 (priority?), *operculata*, *tenkatei*, *tjibodae*, *sexta*; sub-spp ("varieties") *capensis fasciata* (Rosa, 1892), *capensis willeyi* (Benham, 1895), *capensis inflata* (Horst, 1893) syn. *parva* Ude, 1893, *capensis sumatrana* (Horst, 1883) – cf. *M. californica*. Note: this and some of these synonyms noted above with "?"s are questionable and doubtful].

Pheretima javanica: Gates, 1939: 413; 1958: 21.

Metaphire javanica: Sims & Easton, 1972: 215-216 (syns. *sumatrana*, *inflata*, and

possibly others from the 38 names in their "*javanica-group*"?). [Note: Sims & Easton (1972: 243) mistakenly cite the taxon as "*Amynthas javanicus*", and on page 244, 260-261 they mistake the name "*M. javanica*" for *P. martensi javana*; their inclusion in synonymy of *sumatrana* and *inflata* allowed comparison with Michaelsen's concept of *capensis* and its synonyms, now probably mistaked as *inflata* at least has a widely different spermathecal diverticulum. Probably all (but *sumatrana*?) should be considered separately].

Taxonomic Note: My idea that *M. javanica* is debatably synonymous with *M. californica*, which apparently has page priority ("position precedence"), was formed partly due to Easton (the co-author of the genus) misidentifying Queensland specimens. But this has possibly less validity since the spermathecae at least differ in these two taxa. See Remarks below for other possible synonyms.

[This description is compiled from Sims & Easton (1972: 215), Michaelsen (1900), etc.].

Diagnosis: *Metaphire* with male pores 0.2 (or more?) circumference apart in 18. Spermathecal pores two pairs ca. 0.3 circumference apart in 7/8/9. Genital markings absent. Caeca simple with smooth margins apart from intersegmental constrictions, paired 27-23,24.

Distribution: Java, Indonesia and Timor, ?Barbados, China (Hongkong), South Africa. Disconfirmed from Australia: - Blakemore (1999) questioned the Queensland report (by Jamieson, 1977); a later footnote by Jameieon (2000: 82) querying Blakmore (1999) claimed "(here confirmed for Queensland, W 2682)" but is misinformative - see the correct description and figure of specimen AM W2682 in the account of *M. californica* above. Thus, justification for the query by Blakemore (1999) is reaffirmed, and the report of *M. javanica* from Australia is yet again dismissed].

Behaviour: "*[A]s active as a snake and hard to catch*" Gates, 1958 (cf. *M. californica*).

Length: 50-130 mm.

Width: 3-5 mm.

Segments: 80-110.

Colour: Brown.

Prostomium: Epilobous.

First dorsal pore: 6/7-12/13,13/14.

Setae: Numerous ca. 45-50 per segment e.g. 43-47/se.g. 7; 38-40/se.g. 8; 56-60/se.g. 17; 44-56/se.g. 20, aa=ab; setae sometimes missing on clitellum.

Nephropores: Not reported.

Clitellum: Annular 14-16.

Male pores: Ca. 0.2 circumference apart in copulatory pouches on 18 (Michaelsen, 1900; Sims & Easton, 1972: 215 – although they do not state how deep these are).

Female pores: Single on 14.

Spermathecal pores: Two pairs ca. 0.3 circumference apart in 7/8/9 (Sims & Easton, 1972: 215).

Genital markings: Absent.

Septa: 4/5-7/8 thickened; 8/9 and (sometimes?) 9/10 absent; 10/11 thickened.

Hearts: Last hearts 13.

Gizzard: Between 7/8 and 9/10.

Calciferous glands: Oesophageal pouches absent.

Intestine origin (caeca, typhlosole): 15-16; caeca simple with smooth margins apart from intersegmental constrictions, paired 27-23,24.

Nephridia: Meroic.

Male organs: Testes/funnels holandric in testis sacs, seminal vesicles paired in 11 and 12; coelomic pouches paired on septa 12/13 and ?13/14.

Ovaries: Paired 13.

Prostates: Racemose, large 16-22, ducts S- or U-shaped pass into copulatory pouches that each contain a small penis-like papilla but that apparently lack glandular pads and stalked glands.

Spermathecae: Two pairs in 8 and 9; small duct shorter than ampulla; diverticulum slender, longer than ampulla (and may be highly convoluted, sometimes coiled like a ram's horn – this now doubtful) and with an ovoid seminal chamber (always?).

Remarks: The above account is mainly extracted from Sims & Easton (1972: 215) who based their description on examination of the holotype, and types of synonyms *sumatranus* Horst, 1883 and *inflata* Horst, 1893: also on the descriptions of Michaelsen (1900: 259), who provisionally and questionably combined prior *javanica* Kinberg 1867 with the succeeding *capensis* Horst, 1883 – this now considered to be mostly in error.

Michaelsen (1900: 260) had four varieties of *P. capensis*, these were: *sumatrana* (Horst, 1883); *fasciata* (Rosa, 1892); *inflata* (Horst, 1893) (syn. *Perichaeta parva* Ude, 1893); and *willeyi* (Benham, 1895) (non *Megascolex willeyi* Michaelsen, 1909). Because *javanica* has prioity over *capensis*, I suggested these names be combined but was uncertain about the status of the *fasciata* and *willeyi* 'varieties'. It seems that *inflata*

at least should remain separate on its peculiar spermatheca shown by Horst (1893: pl. X fig. 8). A later subspecies, *Metaphire inflata cai* (Michaelsen, 1916), is herein raised to species level as *M. cai* because it has a single pair of spermathecal pores in 8/9 (Sims & Easton, 1972: 217, 238).

It appears to this author that *Metaphire javanica* s. strict. is almost identical to, if not synonymous with, the prior *Metaphire californica* - the main differentiation is that the spermathecal and male pores are reported as slightly less wide in some accounts of *M. javanica*. Also Horst's *sumatrana* has perhaps more rounded spermathecal diverticula on longer stalks. Moreover, it appears that *M. californica* has intestinal caeca that are variously smooth or incised. Synonymy of this taxon would not affect the validity of the genus *Metaphire*, it would just substitute *M. californica* as the type-species.

Despite a greater numbers of species recorded since Sims & Easton (1972), it is nevertheless possible that some synonyms of both *californica* and *javanica* may be restored, this confounded by residual confusion persisting in pheretimoid taxonomy. DNA can help resolve such issues, especially if based on types.

Kinberg's brief original description was:

"Ph. javanica *n. Cingulum segmenta corporis 12 et 13 occupans; tubercula ventralia inter segmentum 14 et 15; setae segmenorum anteriorum 48-50:nae, meiorum 50:nae, posteriorum 62:nae; segmenta 55; longitudo 75 m.m. Java*."

Metaphire malayana (Beddard, 1900)

Amyntas malayanus Beddard, 1900: 893. [Type locality Aring, Kelantan State, Malaysia. Types listed by Reynolds & Cook (1976: 133) in British Museum as BM: 1904:10:5:89, 1924:2:1:135-6 and in the University Museum Cambridge. Syntype(s) BM:1904:10:5:89 inspected by Sims & Easton (1972: 181, 239) who put it in a *Metaphire malayana* group. Stephenson (1932: 220) re-examined specimens in two jars, one labeled "Types" from Aring, Kelantan State; Skeat Expedition, 17.viii.1899, and containing two specimens only one of which was mature and dissected; the second jar had a single undissected mature specimen]. [Genital papillae were paired on the hinder third of each of segments 18, 19 and 20 in both mature specimens (although Beddard had four pairs in 18-21), a little within the lines of the prominent male pores].

Pheretima malayana: Stephenson, 1932: 220; Gates, 1949: 27; Gates, 1972: 199 (syns. *baruana, evansi, pulauensis*, *fovella, strellana*).

[?*Amyntas pulauensis* Beddard, 1900: 904. [From Pulau Bidan, Kedah State, Malaysia. There is a discrepancy with the types stated by Reynolds & Cook (1976: 159) to be BMNH 1904:10:5:1002, 1924:3:1:214-5 but Sims & Easton (1972: 181) claim syntype(s) as BM.1904.10.5.214/215; Stephenson (1932: 233) re-examined two "Types" in one jar from Pulau Bidan and a third specimen in a jar from 'Malay Peninsula']. [Note: name misspelt "pulanensis" in introduction by Beddard (1900: 892); also often misspelt "palauensis" or "puluensis", non *palaoensis* Ohfuchi, 1941. This taxon was included in *malayana* by Gates (1972) although Sims & Easton (1972: 217, 239) have it in an *Metaphire pulauensis* species-group with "genital markings unpaired, midventral" that includes just *pulauensis* and *baruana*, rather than the *Metaphire malayana* species-group defined with paired markings "on 19, 20, 21, etc.". This is a mistake as *baruana* has markings in 18 (unilateral on a side but probably paired when fully developed) unlike *pulauensis* that has numerous midventral markings and is diagnosed separately below].

?*Amyntas evansi* Beddard, 1900: 907. [From Biserat, Malaysia. Types stated by Reynolds & Cook (1976: 99) to be BMNH 1904:10:5:37 and 1924:3:1:216-8; both lots inspected by RJB 19.VI.2013 (the former has one dissected syntype, the other has two syntypes, both dissected, that all agree superficially). Stephenson (1932: 213) re-examined two jars, the first labeled "*types: Biserat, May 1899: Skeat Expedition"* with three specimens, and the second also labeled "*Biserat*" with a single specimen (although Beddard said he only got three specimens originally). Syntype(s) B.1904.10.5.37 inspected by Sims & Easton (1972: 180, 235) who put it in the broad *Amynthas diffringens* (= *A. corticis*) species-group although it seems unlikely to be a synonym, of *A. corticis*]. [Stephenson (1932: 213) described the largest of the "types" with length 120 mm having male apertures on 18 on large porophores by which the furrows 17/18 and 18/19 were somewhat bulged, about 0.3 circumference apart, with 17 or 18 setae intervening. The distinctive genital papillae were a series of about 13 or 16 small discs across the middle of furrow 7/8 between the spermathecal pores (these discs missing from the other two 'types' although the single specimen in the second jar not labeled 'types' were well marked with 16 across the furrow - just as figured by

Beddard); no other markings were described so they are absent from male pore region although the 'accessory' gland internally in 18 may indicate normal presence of markings in this segment].

?*Pheretima baruana* Stephenson, 1932: 209. [For specimens from Khota Baru (or Khota Bharu or Kota Bharu), Malaysia misidentified by Beddard (1900: 892) as *P. bosschae* Horst. Two syntypes in British Museum BM:1904:10:5:14 inspected by Sims & Easton (1972: 180, 239) who (erroneously?) placed it in a *Metaphire pulauensis* species-group separate from *M. malayana* species group as noted above]. [Stephenson (1932) describes its markings on 18 thus: "*A small flat-topped circular secondary papilla with pigmented center is present on the inner slope of the left porophore; the median region between the porophores is depressed. In the second specimen there is a similar secondary papilla, here also on the left side*;" these markings probably paired in fully matured specimens].

Pheretima flovella Gates, 1949: 21. [From Kaki Bukit. Types in Raffles Museum].

Pheretima strellana Gates, 1949: 34. [From Baling. Types in Raffles Museum].

Metaphire malayana; Sims & Easton, 1972: 239. [In an *M. malayana* species-group that includes these species: *malayana, fovella, strellana*, and *grossa* Goto & Hatai, 1898 that is now in synonymy of *A. fuscatus* (Goto & Hatai, 1898)].

Taxonomic Notes: It seems that several taxa placed under "*Amyntas malayanus*" or "*Pheretima malayana*", now *Metaphire malayana* (Beddard, 1900), by Gates (1972: 199) require review as they are distinct in their genital markings and superficial or only slightly invaginated male pores. Following Blakemore (2003), *Pheretima grossa* is now removed from this group as this taxon is in synonymy of *Amynthas fuscatus* (Goto & Hatai, 1898) which is itself similar to *Amynthas juliani* and *Metaphire bipora* - all have paired genital markings in line with and behind the male pores. It is certain that *A. evansi* does not belong with *M. malayana*; in Sims & Easton's (1972) matrix, it grouped closest with *diffringens* (= *A. corticis*) and also with *baruana*, *bipora*, *masatake*, and *himalayana*. This conclusion confirmed from inspection of BMNH syntype (RJB 19.VI.2013).

The following description is based on the original and re-descriptions from Stephenson (1932), Gates (1972) and Sims & Easton (1972) but with reservations on some of the synonyms, as noted above. There is a separate diagnosis of *Metaphire pulauensis* below.

Remarks See below as it appears likely that this taxon is different from *M. malayana.*

Diagnosis: *Metaphire* with paired spermathecal pores ca. 0.25 body circumference apart in 5/6/7/8/9. Male pores (?on penes and slightly) invaginate, if superficial then it would qualify for *Amynthas*. GMs typically paired in (18), 19, 20, 21 posteriorly on segments a little within the lines of the male pores. Secondary (pseudo-)copulatory pouches absent (cf. *Metaphire bipora*).

Distribution: Malaysia. Said by Gates (1972: 172) to extend into Thailand and to overlap in the south with that of *M. bipora* thus a widespread species, but it is possible that his synonymy list is too wide.

Habitats: Geophagous so possibly a subsoil species?

Behaviour: Geophagous; reproduction biparental?

Length: 144 mm (type, range?).

Width: 5 mm.

Segments: 97 (type, range?).

Colour: Dark grey (clitellum almost black).

Prostomium: Prolobous? or epilobous.

First dorsal pore: 11/12.

Setae: Numerous (ca. 47-59).

Nephropores: ?

Clitellum: Annular 14-16.

Male pores: (Invaginated) on prominent porophores on 18 ca. 0.25-0.3 circumference apart; with 16-18 setae between.

Female pore: On 14.

Spermathecal pores: Four pairs in 5/6/7/8/9 ca. 0.25 circumference apart.

Genital markings: Marking paired discs posteriorly in some or most of 18,19–20,21 a little inside the line of the male pores. Other markings not noted. (Cf. a line of papillae papillae found in furrow 7/8 and two similar rows of 8 papillae between male pores in *Metaphire evansi* – pers. obs.).

Septa: 8/9/10 aborted, 7/8, 10/11-12/13 thickened.

Dorsal blood vessel: Single?

Hearts: Last pair in 13.

Gizzard: As usual.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): Caeca simple in 27-23; typhlosole?

Nephridia: Meroic.

Male organs: Testes/funnels holandric; testis in 10 and 11 in sacs; seminal vesicles in 11 & 12, sometimes with dorsal lobes.

Ovaries: In 13 with funnels; no ovisacs.

Prostates: Small, racemose in 17-19, ducts short (copulatory sacs not visible). Stephenson (1932: 211) describes *baruana* with an "accessory prostate" on each side ventrally embedded in the body wall in 18-20 that is apposed to the actual prostate on each side (probably genital glands).

Spermathecae: Small in 6-9; large ampulla, diverticulum extal with irregular loops within connective tissue terminating in seminal chamber.

Gut contents: ?

Remarks: Stephenson (1932: 203) described similarly convoluted stalks to the spermathecal diverticula of *baruana, evansi* (this not seen in syntype on inspection by RJB), and *papulosa* as well as *malayana*; moreover, *baruana* and *evansi* had "*accessory prostates*" that he also noted in his redescription of *bipora* and *virgo*. It is probable that these "*accessory prostates*" are actually sessile glands associated with the paired genital makings typically found just median to the male pore line in these segments (not externally manifest in *evansi*). Interestingly, just such arrangements of spermathecae and genital markings are found in the Japanese *A. fuscatus* and Vietnamese *A. juliani*, possibly indictive of close affinity within this group of taxa.

Gates' (1972: 199-200) broad classification claimed male pores on penes pendent from the roof of small copulatory chambers and genital markings in some of 6-9 and 17-24. He said that relationship appears to be especially close to *M. bipora* but that "much more information is needed about several characters in the *malayana* range." It is difficult to clearly attribute several of these taxa to either *Amynthas* or *Metaphire*, nor to determine whether intestinal caeca are smooth or slightly incised. However, Gates' synonymy of *P. pulauensis* is probably unnecessary and this taxon is described separately here:-

Diagnosis of ***Metaphire pulauensis*** (Beddard, 1900: 904) from Stephenson's (1932: 233) re-examination and redescription of the three British Museum types.

Location: Pulau Bidan, Kelah, and Aring, Malaysia.

Biometry: 143-165 by 5-6 mm. Light brown colour. Segments 104-110. Prostomium epilobous or almost tanylobous. Dorsal pores from 12/13. Setae 28-68. Clitellum 14-16. Male pores on 18 with puckered lips about 0.25 circumference apart with 10-12 setae intervening. Female pore on 14. Spermathecal pores small in 5/6/7/8/9 ca. 0.3

circumference aprart. Genital papillae are numerous and aggregated to form quadrangular cushions, mid-ventrally and in front of the setal ring on 7, 8, 9, 17 and 18. The papillae are arranged in 1 to 4 not very distinct transverse rows in the cushion on 7, in ca. 4 rows on 8, in ca. 5 rows on 9, and in ca. 3 or 4 rows on each of the hinder cushions. (Beddard's original figure mistakenly shows the cushions in 7 and 17 that should be in further in front of the setal rings).

Septa 8/9/10 are aborted, 10/11-14/15 thickened. Gizzard is as usual. Caeca are smooth from 27-24. Last hearts in 13. Sperm sacs are paired in 10 and 11; seminal vesicles in 11 and 12. Prostates lobular in 17-20. Ovaris and funnels in 13; ovisacs in 14. Spermathecae in 6-9 have large ampulla, and smaller looping diverticulum ectally. Aggregated glands correspond with the external markings.

Remarks: Contrary to Gates (1972) and Sims & Easton (1972), *Metaphire pulauensis* appears quite separate from either *Metaphire malayana* or *M. baruana* as they are diagnosed above, not least for its distinctive genital marking cushions.

Metaphire musica (Horst, 1883)

Photo 1 of worm (courtesy of Hari Nugroho, April, 2006).
Photo 2 of worm habitat (courtesy of Hari Nugroho, April, 2006).

["Sondarie-worm" Vorderman, 1882: 111].

Megascolex musicus Horst, 1883: 193. [Locality high mountain forests, Java, Indonesia. Types in Leiden, 1960, 1956].

Perichaeta musica: Michaelsen, 1892: 238; Horst, 1893: 328.

?[*Perichaeta longa* Michaelsen, 1892: 239. [From Kepahiang, Sumatra (Type locality). Types in Berlin Museum]; Horst, 1893: 326].

Pheretima longa : Gates, 1937: 321; 1948: 153-156. From Tjiseureuh (Ciseureuh), Sindanglaya, West Java (with note "*Mus. Zool. Bogor.,* Megascolex musicus")].

Amyntas musicus: Michaelsen, 1899: 22.

Pheretima musica: Michaelsen, 1900: 287 (syn. *longa*); Gates, 1948: 157-159.

Metaphire musica: Sims & Easton, 1972: 238 (*javanica* group).

Notes: The following description from Horst (1883); Michaelsen (1900) and Gates (1948) with notes from Hari Nugroho (pers. comm. April, 2006) who reports:

"*This species is known as "cacing sonari" (cacing = worm) by local people surrounding Gunung Halimun National Park and Gunung Sawal Nature Reserve. The habitat is mainly on epiphytic fern (*Asplenium *spp) and sometimes found on dead-rotten trees. It believed by local people as a traditional medicine againsts fever. Some peoples around Gunung Halimun National Park told that this kind of earthworm have ability to make some sounds like a cricket*". This noise is perhaps actually made by crickets...

Diagnosis: *Metaphire* with paired spermathecal pores in 7/8/9. Male pores 0.25-0.3 circumference apart in 18 (in copulatory pouches). Intestinal caeca manicate (in 27).

Distribution: Central Java (e.g., Buitenzorg, Tjibodas, Gedeh, Bantam - Michaelsen, 1903), where it is probably indigenous and called "*tjatjing sondarie*" or singing worm.

Habitat: "*living in the high mountain forest and [they] make a sharp interrupted noise during the night*" (Vorderman pers. comm. to Horst).

Behaviour: 'sings'? – unlikely but possibly other organisms (crickets?) in the habitat do.

Length: 370-570 mm (210 mm Horst).

Width: 10-22 mm (18-22 mm Gates; "48mm" or 17 mm Horst).

Segments: 132-166 (65 Horst).

Colour: "*above greyish-blue, lead-coloured, underside paler, rufous; girdle brownish; genital pores, mouth and vent yellowish*" (Horst, 1883).

Prostomium: Epilobous, but almost tanylobous.

First dorsal pore: 12/13/14.

Setae: Numerous, 50-100 per segment (Gates has fewer, around 20-30 per segment).

Nephropores: Not reported.

Clitellum: Annular 14-16, setae absent.

Male pores: 0.25-0.3 circumference apart on 18 (in "*slits*" = copulatory pouches?).

Female pores: Single on 14.

Spermathecal pores: Two pairs ventro-lateral in 7/8/9.

Genital markings: None.

Septa: 4/5-6/7 and 11/12-13/14 thickened, 8/9/10 aborted, 7/8 thin.

Dorsal blood vessel: Single.

Hearts: 9,10 - 13.

Gizzard: In 8(?).

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): "*like* Megascolex Sieboldi [(sic) = *Metaphire*

sieboldi] *the intestine is provided on each side of the 26th segment with six caeca, of which the superior is the longer, however this seems to be not a constant characteristic, in one of* [the two] *specimens only the superior caecum being present*" (Horst, 1883). "*Intestinal caeca are compound, the dorsal-most secondary caecum much the longest, the other two to five secondary caeca also anteriorly directed*" (Gates). Typhlosole lamellar from 27.

Nephridia: Meroic.

Male organs: Testes/funnels in sacs in 10, 11; seminal vesicles in 11 and 12; pseudovesicles may be present in 13,14. Often parasitic cysts present in vesicles (Gates).

Ovaries: "*Bunch-like ovaries in the 14th segment, hanging on the posterior side of the 13th segment*" (Horst, 1883).

Prostates: "*large prostatic glands, divided in numerous lobes*" (Horst, 1883).

Spermathecae: Two pairs, ampulla saccular with short duct, and long tubular diverticulum "*rolled up in numerous windings*" (Horst, 1883).

Gut contents: ?

Remarks: It is included because of its possible comparison with cosmopolitan *D. schmardae* and due to some other taxonomic uncertainty. Placed in *Metaphire* by Sims & Easton (1972) although Michaelsen's description suggests that copulatory pouches are absent (*Amynthas*?), it is probably endemic to its region and its large size suggests it may not be easily transported. Gates (1937; 1948) noted that of the two specimens of *M. musica* (Horst, 1883), the one with simple intestinal caeca belongs in *M. longa* (Michaelsen, 1892) that was placed in *Metaphire* by Sims & Easton (1972: 238). Specimens of *M. longa* described by Gates were 305-440 mm long and dark blue/black coloration; their size suggests that they were fully developed matures, yet their caeca were simple and smooth. Its distribution was Kepahiang, Sumatra and Sindanglaia (1,200m); and Mt Salak (800m) near Buitenzorg, Java.

Beddard (1900) included it in his *Amyntas aeruginosus* but this is possibly a mistake (cf. he also seems to have combined *californica* misidentifications with *schmarda*).

Sims & Easton (1972: 181) claimed British Museum specimens (1891:5:4:2/4 - not types) they inspected were *M. musica* but, as the intestinal caeca were simple (pages 193, 217), possibly these specimens are actually *M. longa* too that may thus warrant restoration from synonymy by Michaelsen (1900) due to its non-complex caeca, as indeed Gates (1948) applied such a restoration.

Metaphire peguana (Rosa, 1890)

Fig. 2.3.3a *M. peguana* after Rosa's original figs. 6-8 (V = mid-ventral line).

Fig. 2.3.3b *M. peguana* coiled spermatheca after Stephenson, 1932: fig. 5.

Fig. 2.3.3c. *M. peguana* vs. *M. saigonensis* after Omodeo (1956: figs. 1, 2).

Fig. 2.3.3d *M. saigonensis* after Omodeo (2000: fig. 9D) (p = prostate, su = GM sucker); the spermathecae shown on lhs have uncoiled diverticula unlike *M. peguana* proper and appear to be based just on the spermatheca in 7lhs of Omodeo (1956: fig. 4).

Perichaeta peguana Rosa, 1890: 113, figs. 6-8 (pg. 1057). [Type locality Rangoon. Types in Genoa, 44037 or, from Gates, 1925: 327, Cat. No. 46]; Rosa, 1898: 289 [material in London from Chantaboon, Siam (also inspected by Beddard?) that allowed modification of original account].

Amyntas peguanus: Michaelsen, 1899: 7; Beddard, 1900a: 628.

Pheretima peguana: Michaelsen, 1900: 292; Stephenson, 1923: 308, 1932: 49, fig. 5 (of spermatheca); Gates, 1925: 561; 1937: 327; 1972: 207 (syn. *saigonensis*). Non Ohfuchi, 1957: 171 from Okinawa which seems to be an *Amynthas* or at least different in several regards, as noted by Gates (1972: 209).

Pheretima (*Pheretima*) *peguana* : Omodeo, 1956: 325, figs. 1, 3, 5. ?Non Michaelsen, 1922: 44 (cf. *M. saigonensis*).

?[*Pheretima saigonensis* Omodeo, 1956: 327. Type locality Saigon. Types Verona, 15].

Metaphire peguana, Sims & Easton, 1972: 239 (*peguana-group*); Easton, 1981: 58; Blakemore, 2002, 2006, 2008, 2010, 2012, 2016.

Dignosis: Spermathecal pores paired, c. 0.3 circumference apart in furrows 6/7/8/9. Male pores within copulatory pouches on segment 18. Genital markings paired ellipses with central apertures across 17/18 and 18/19. Spermathecal diverticula much coiled. Intestinal caeca simple with smooth margins, originating in segment 27.

Distribution: Myanmar; Thailand; Vietnam; Cambodia (Thai & Do, 1989); Penang, Malaysia; Singapore; Java (? cf. *M. saigonensis*); Borneo (Myanmar); St Paul's Cathedral Calcutta, Indian Botanic Gardens, Howrah (Ref.); Tripura and Dhaka, Bangladesh (Ref.1, Ref. 2, 2012) and, doubtfully, Japan as Gates (1972: 209) questioned the identity of the Ishigakijima, Ryukyu Islands record that was retained by Easton (1981: 58). Earlier Ceylon reports are for *M. bahli* not *M. peguana* proper.

Locality: Not recorded from Australia, but peregrine in the region (cf. *Metaphire bahli*).

Habitat: Soils of gardens, lawns, banana groves and other sites in town and jungle. Claimed as vermicomposer called the "redworm" in Thailand (misidentification?).

Behaviour: ?

Length: 104-240 mm.

Width: 5-8 mm.

Segments: 71-124.

Colour: Grey-brown, bright reddish in dorsum.

Prostomium: Open epilobous.

First dorsal pore: 12/13.

Setae: Numerous (ca. 30-72).

Nephropores: ?

Clitellum: Annular 14-16.

Male pores: Lateral slits of copulatory pouches in 18 with about 8-18 setae between.

Female pore: On 14.

Spermathecal pores: Three pairs in 6/7/8/9 ca. 0.3 circumference apart with about 18-24 setae inbetween.

Genital markings: Superficial elliptical pads with slit-like apertures in 17/18 and 18/19, or rather on the posterior and anterior halves of segments 17 and 19, respectively, just median to the male pores (with genital glands, almost sessile, internally). [These markings are more inverted in the similar *M. bahli*].

Septa: 8/9/10/11 aborted [?10/11 is characteristically aborted, 8/9 may be partially present or vestigial; Rosa, 1898 had missing septa in just 8/9/10), 11/12-12/13 thickened].

Dorsal blood vessel: Single.

Hearts: Commissurals in 8-9(,10) and latero-oesophageal in 10-13.

Gizzard: In 8.

Calciferous glands: Absent although oesophagus may be swollen in 10-13.

Intestine origin (caeca, typhlosole): In 15; caeca "*wie gewöhnlich*" (as usual) simple in 27-22; typhlosole small.

Nephridia: Meroic.

Male organs: Testes/funnels in 10 and 11 in sacs; seminal vesicles in 11 and 12.

Ovaries: In 13.

Prostates: Racemose in 16-21, ducts long.

Spermathecae: Small in 7-9 with duct shorter than ampulla and diverticulum that has

slender much looped stalk (sometimes encased in mesentery?) with ovoid seminal chamber terminally.

Gut contents: ?

Remarks: "*Pheretima peguana*" is claimed to be cultivated commercially in Thailand (Ref.).

Gates (1972: 209) says that one or more of the genital markings in 17/18 and 18/19 are occasionally absent and preservation may cause eversion of male copulatory pouches. He included *saigonensis* in synonymy because the differences by which it was distunguished "*are quantitative, trivial, and of characters liable to more or less individual variation in the genus*." However, the figure from Omodeo (1956: figs. 2, 4 and 2000: fig. 9D) shows it to have male and spermathecal pores closer and spermathecal diverticula that are not quite as coiled as in *M. peguana* proper. Thus it seems that *M. saigonensis* from Vietnam should be retained separately. Moreover, Omodeo (1956: 325) thought that Michaelsen's (1922: 44) description of *Ph. peguana* possibly refers to *M. saigonensis* which – if really the case – would expanded its distribution to Indonesia. [Omodeo (1956: 326) says: "*Gli esemplari di Michaelsen (1922) hanno provenienza assai piu meridionale: Tandjoengpriok presso Batavia (Giava) e baia di Laboeau nell'isola Lombok*" – Michaelsen's (1922) specimens are more southerly from Tandjoengpriok Harbour at Batavia (= Jakarta, Java) and Bay Laboeau on Lombok]. Until confirmation I suggest confining *M. saigonensis* to its type.

Metaphire bahli (Gates, 1945) from Sri Lanka, Laos, Vietnam (Thai & Samphon, 1989; and Ref.), Cambodia (Ref.), Australia, the Philippines and Thailand is almost identical to *M. peguana*, its main morphological difference is that the gential markings are found to be always invaginated.

Recent molecular studies by Nguyen Tung *et al*. (2012: tab. 1; fig. 1) have shown 10.5% DNA COI barcoding differences of their *M. peguana* and *M. bahli* from the Mekong delta region of Vietnam (Ref.). Cf. barcoding attempt of "the red worm (*Pheretima peguana*)" (sic) from Thailand Ref:-

Loongyai, W., Bangrak, P., Chantsavang, S. (2011). External morphological comparison, taxonomic revision and molecular differentiation of the four economically important species of earthworms in Thailand. *International Journal of Agriculture & Biology.* 13(4): 553-558.

Also compare to molecular studies from Thailand (Ref. 2013; Blakemore, 2016).

Metaphire planata (Gates, 1926)

Fig. A11 from Thailand ex Pattna thesis (2008: 144).

Pheretima planata Gates, 1926: 411]; Gates, 1972: 211. [Type locality Rangoon. Topotypes in US National Museum].

Metaphire planata; Sims & Easton, 1972: 217, 239 (*planata*-group with spermathecal pores in 6/7/8 and simple intestinal caeca).

Dignosis: Spermathecal pores paired close to 6/7 and 7/8 in 7 and 8. Male pores within copulatory pouches on segment 18. Genital markings small circular just median to each spermathecal pore in 7-8; and on roof and walls of each copulatory chamber. Intestinal caeca simple with smooth margins, originating in segment 27.

Distribution: Andaman Islands (India), Myanmar, Chiengmai and Ko Chang (Thailand), Assam, Bengal, Dacca (Bangla Desh = Bangladesh), Jharkhand State East Central India, Selangor, Kuala Lumpur (Malaysia). Abundant on Andamans and widespread but rare elsewhere; original homeland unknown. Finding this worm in gardens by Dak bungalows made Gates suggest it was initially introduced to Burma with exotic plants although it is widespread in that country.

Locality: Not recorded from present studies.

Habitat: Garden soils?

Behaviour: ?

Length: 64-176 mm.

Width: 4-7 mm.

Segments: 115-142.

Colour: Reddish-brown to slate in dorsum.

Prostomium: Rudimentary or lacking.

First dorsal pore: 10/11/12.

Setae: Numerous (ca. 20-80).

Nephropores: ?

Clitellum: Annular 14-16.

Male pores: Small in lateral slits in copulatory pouches of 18.

Female pore: Median on 14.

Spermathecal pores: Two pairs close to 6/7 and 7/8 in 7 and 8.

Genital markings: Small circular just median to each spermathecal pore in 7-8; and on roof and walls of each copulatory chamber.

Septa: 6/7/8 thickened, 8/9/10 aborted, 10/11/12/13 slightly thickened.

Dorsal blood vessel: Single.

Hearts: Commissurals in 8-9,10, and latero-oesophageal in 11-13.

Gizzard: In 8.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): In 15; caeca simple in 27-20; typhlosole small.

Nephridia: Meroic.

Male organs: Testes/funnels in 10 and 11 in sacs; seminal vesicles in 11 and 12.

Ovaries: In 13.

Prostates: Racemose in 16-21, ducts U-shaped.

Spermathecae: Large in 7 and 8 with duct elongate, "*diverticulum longer than main axis, with short stalk, thicker middle portion in wall of which there are numerous microscopic chambers, and an elongately ellipsoilda, terminal seminal chambers*."

Gut contents: ?

Remarks: Gates (1972:212) thought this species "*markedly anthropochorous*", its distribution due to human transportation from an homeland as yet unknown.

Metaphire posthuma (Vaillant, 1868)

Fig. 2.20a *M. posthuma* from Vaillant, 1869: fig. 9.

[Fig 2.20a' "*Perichaeta cingulata*" from Vaillant's original 1868: figs. 1-8].

Fig. 2.20b *M. posthuma* synonym *Pheretima affinis* from Perrier's fig. 66.

Fig. 2.20bc sketch of *M. posthuma* lower rhs cf. pheretimoids ex Easton (1982: fig. 4).

Fig. 2.20d photo of new Mindanao specimen male field (by RJB Feb., 2014).

Figs. 2.20e photos from Taiwanese website.

Fig. 2.20f sketch from Sims & Gerard, 1999: fig. 47d.

Fig. 2.20g Beddard 1886: fig. 7 supposedly of an abnomal specimen's spermathecae.

Fig. 2.20h Michaelsen 1889: fig. 17 of *A. quadripapillatus* spermatheca.

Perichaeta posthuma Vaillant, 1868: 228, "pl. 1, figs. 1-8" (actually I cannot find pl. 1 and pl. 10, figs. 1-8 are of "*Perichaeta cingulata*" only! However the next publication has correct figures); 1869: 146, pl. 6, figs. 9-11 (of *P. posthuma* male field, a seta, and vascular system showing hearts in 9-13, respectively; note that his 1869: figs. 1-8 are of *P. cingulata* exactly as in the 1868 paper).

[Type locality Java. Types in Paris Museum, possibly AE656-668]; Horst, 1883: 186 (syn. *affinis* Perrier); 1893: 61, t. 3, fig. 30 (of a spermatheca); Beddard, 1895: 424; 1886: 93, fig. 7 (probably of a different polythecal species!); Michaelsen, 1896: 201.

Perichaeta affinis Perrier, 1872: 106, fig. 66; 1875: 1044. [Type localities Saigon (where it is called "*Trung Ho*" in the local Andamanese) and Luzon, P.I. Types in Paris, possibly AE669 (Luzon) and AE663+671 (Saigon) although Jamieson (1975: 143) also illogically includes AE660-662 (Saigon) and AE664-668 from Cochinchine collected by M. Julien in 1874(!) and AE670 from Bataan l'île de Luçon collected by M. Lalaize in 1876(!) ridiculously as "*TYPE*"s of this species that was described in 1872! – cf. *P. luzonica.* Reynolds & Cook (1976: 65) give types of *affinis* as MNHN 669-72 without embelishment although they also give overlapping MNHN 656-71 as types of *posthuma* that they appear to miscite as Vaillant, 1868: "*146*"]. Beddard, 1890: 52, Pl 5, figs. 1-3,11; Beddard, 1892: 214.

Megascolex posthumus: Vaillant, 1899: 72, pl. XXI, figs. 12-13 (syn. *affinis*).

Amyntas posthumus : Michaelsen, 1899: 74; 1900: 297; Beddard, 1900: 641.

?*Amyntas quadripapillatus* Michaelsen, 1899: 93, fig. 17 (of a spermatheca). [From Sumatra, Bindjey Estate. Types in Hamburg missing?]. **Syn. nov.**?

Pheretima posthuma: Michaelsen, 1900: 295 (syn. *affinis*); Stephenson, 1912: 278; 1917: 385; Bahl, 1919: 69, fig. 1; Stephenson, 1923: 309 (syn. *affinis*); Gates, 1926: 464; 1930: 321; 1931: 405, 487; 1932: 487; 1936: 391; 1937: 363 (syn. *affinis*); 1937: 365 (but not much use as he reports that *affinis* was described by Beddard, 1887!); 1939: 104; 1959b; 1960: 271; 1972: 212; 1982: 61 (syn. *affinis*); Omodeo, 1956: 325; Nguyen, T.-T, 2013: 56, figs. 2.5, 3.11 (syn. *incerta, rhabdoida* Chen, 1938 – this latter not confirmed as taxon in *Amynthas*).

Pheretima incerta Beddard, 1912: 197. [From immediate neighborhood of the Bureau of Science building, Manila, Luzon, Philippines. Types?]. [It seems to me that there are few reliable characters cited to separate this taxon from *M. posthuma* apart from last hearts supposedly in segment 12. Note: Sims & Easton (1972: 237, 243) and Reynolds & Cook (1976: 116) misspell the subspecies name of *Amynthas kanrazanus incretus* (Kobayashi, 1937) as "*incertus*" and the former authors erroneously say "*(non Beddard, 1912)*" confusing it with *P. incerta*, thus no replacement name is required]. **Syn. nov.**

?[*Pheretima rhabdoida* Chen, 1938. From Hainan. Types? This is unlikely as the taxon,

supposedly having superficial male pores, is now held in *Amythas*].

Metaphire posthuma: Sims & Easton, 1972: 239 (*posthuma*-group); Sims & Gerard, 1985: 132, fig. 47d; Blakemore, 2002, 2006, 2008, 2010, 2012 (syns. as above).

Note: Some authors list species as *Metaphire posthuma* (Vaillant, 1869: 146).

Dignosis: Spermathecal pores paired, c. 0.3 circumference apart in furrows 5/6/7/8/9 (or 6/7/8/9 e.g. in *affinis*, only one pair in *incerta*, or variously aborted?). Male pores within copulatory pouches on segment 18 (shown everted in *affinis*). Genital markings large paired on either side of male pores centered on the equators, at most in 14 - 30 at least and usually in 17 & 19. Intestinal caeca simple (small) in segment 27.

Distribution: India (one of most common taxa),), Islamabad and also Kamra in Attock District of Pakistan (Ghaffor, 2003), Bangladesh, Andamans, Seychelles (Gerlech, 2011: 62), China, Indonesia, Christmas Island south of Java (e.g. Michaelsen, 1900; Gates, 1935), Flores (Michaelsen, 1934), Sumatra, Celebes, Great Bastard (Groot-Bastaard) Island (e.g. Horst, 1893: 318), Myanmar, Thailand, Malay Peninsula, Vietnam, Cambodia (e.g. Thai & Do, 1989), Taiwan, Philippines [Luzon, e.g. *affinis*, *incerta* and specimens of *posthuma* from Beddard, 1886 and from Eisen's collection in SI (4551 Ref.), plus Mindanao as **a new record by RJB 2014**], New Hebrides, (= Vanuatu), Santa Cruz (Solomons), Tinian, USA: Florida, Mexico and Bahamas (Dr C. Fragoso pers. comm.), Paramaribo in Suriname (Horst, 1898: 202), Buenos Aires: Argentina, London [Kew Gardens e.g. Beddard (1906: 66) but overlooked by Sims & Gerard, 1999]; Gates (1937: 329) lists it from Takao, Formosa (Taiwan not Takao, Japan); Michaelsen (1935b) reports it from Bahamas and hot-houses in Piedmont (Nizza) in France but Gates (1972: 213) believed that records for Egypt, Bahamas, Argentina and France require confirmation as a Chinese species, *Amynthas hupeiensis*, has been mistaken for *M. posthuma* in the past. Thus the report by Easton (1981: 53) of *A. hupeiensis* (Michaelsen, 1895) from North America and New Zealand may also be questionable [although Edwards & Lofty (1977: 63) lists both taxa from North America].

Locality: Not recorded from Australia, apart from Christmas Island, but a widespread peregrine with potential for colonization. This synopsis is compiled from the descriptions in synonymy references, and from five mature specimens newly collected from Lambaguhon Bgy., San Roque, Iligan City, Mindanao, Philippines in 16th, Feb. 2014 id by RJB with specimens stored in Iligian Institute of Technology – **a new Mindanao record**.

Habitat: Sandy soils and sands of river banks, gardens, mud and manure piles,

especially abundant "*excluively, or almost so*" in riverbanks of the Chindwin, Irrawaddy, Sittang and Salween Rivers (Gates, 1972: 15, 213). Also from paddy fields and their bunds. Note that *M. posthuma* is one of the three species identified (then as *Pheretima affinis*) by Perrier for Charles Darwin (1881: 108, fig. 2) that were (mistakenly?) thought responsible for the "*tower-like castings*" in Nice southern France.

Behaviour: Mass swarming reported from Taiwan (Ref. May, 2006).

Length: 60-140 mm (Iligan specimens up to 120 mm).

Width: 3-8 mm.

Segments: 91-140.

Colour: Light to dark grey or (Stephenson) a rich brown.

Prostomium: Small epilobous or (Michaelsen, Stephenson) tanylobous.

First dorsal pore: 12/13 (rarely 11/12).

Setae: Numerous (ca. 20-140), setae may decrease in number suddenly on 20.

Nephropores: Minute on surface (as with other meroic species described by Bahl).

Clitellum: Annular 14-16 or just short with extent to ¾16; setae absent or some present.

Male pores: In longitudinally crescentic slits of copulatory pouches in 18 ca 0.3 circumference apart (Michaelsen ca. 0.25 U) with about 18-20 setae (or 25-26 according to Horst) between; sometimes everted as blunt, round penes, e.g. in *affinis* synonym types and Mindanao specimens.

Female pore: On 14.

Spermathecal pores: Four pairs in 5/6/7/8/9 ca. 0.3 circumference apart (as seen in Mindanao specimens). [Various Athecal and and Intermediate morphs mentioned by Beddard (1886: 93, 1900) were thought possible misidentifications by Gates (1972: 214) although anterior pair sometimes aborted as in *Perichaeta affinis* Perrier, 1872 synonym having them in 6/7/8/9; *incerta* has maybe only one pair, but Beddard doesn't tell us where! However, Sims & Easton, 1972: 237 place it in the *posthuma*-group].

Genital markings: Paired discs, equatorial median to male pore levels on some or all of 14-30 (listed by Gates 1960: 273) but overwhelmingly defined by a large pair on 17 & 19 in line with the male pores, sometimes displaced, (with sessile genital glands corresponding internally).

Septa: 4/5/6-7/8,8/9 and 10/11 thick, either 8/9 or 9/10 aborted, usually the latter (cf. *A. hupeiensis*).

Dorsal blood vessel: Single.

Hearts: Commissurals in 7-8,9; (pseudo-hearts in 10-11?), latero-oesophageals in 12-13,

Vaillant (1869: fig. 11 shows them in 9-13); (last hearts in 12 in *incerta*).

Gizzard: In 8.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): In 15; caeca simple in 26,27-24; typhlosole present as a slight ridge. [Beddard (1900a; 1912: 199) asserts that intestinal caeca are occasionally absent, but this is doubtful].

Nephridia: Meroic with enteronephric peptonephridia in 4-6 and septal meronephridia ducting to enter intestine dorsally [as with other species as described by Bahl (1919)].

Male organs: Testes/funnels in 10 & 11 in sacs; seminal vesicles small in 11 and larger in 12, or (Stephenson) three pairs in 10-12.

Ovaries: In 13.

Prostates: Racemose in 15-21, ducts long and looped.

Spermathecae: Small in 6-9 with duct shorter than ampulla, and diverticulum entally with short stalk and longer seminal chamber.

Gut contents: ?

Remarks: Michaelsen (1900), whence the *affinis* synonymy comes, allows that the first pair of spermathecae may be deleted. Stephenson (1923: 309) then Gates (1972: 212) provide much information on the biology and ecology of this species, but the latter author did not mention the *affinis* synonym. Beddard's (1912) wordy description of *P. incerta* was nontheless insufficiently distinguished from the prior *M. posthuma* and thus most likely deserves to enter synonymy.

?Metaphire sandvicensis (Beddard, 1896) *sp. incert. sedis.* [cf. ***M. californica***].

Perichaeta sandvicensis Beddard, 1896: 203. [From Lanai, 2000 ft; Mauna Loa, Hawaii, Molokai and from Hong Kong. Type material in British Museum BMNH 1904:10:5:87-88 labelled: "*1904:10:5:87-88 Perichaeta sandvicensis Bedd. 1996 ?SYNTYPES Lanai, Mauna Loa, olokai Ref P.Z.S. 1896: 194-211*"; "*Perichaeta lanaiensis (Lanai) cliff on Mauna Loa, Hawai*" – in Beddard's hand; plus a note from Ed Easton dated 4/2/1974 that this latter is a probable MS name and that the "specimen" (sic) is *M. californica* whereas it actually contains two specimens. Both are dissected, with spermathecal pores in 7/8/9 no GMs and male pores everted or inverted in a small copulatory pouch, with simple intestinal caeca. This pers.obs. RJB VI.2013. Conclusion is *M. californica* Q.E.D.].

Pheretima sandvicensis: Michaelsen, 1900: 300 [spermathecal pores in 6/7/8 – laps.?].

Amyntas hesperidum : Beddard, 1900: 417-419 (syn. *sandvicensis*; ?*annulata*) [spermathecal pores in 7/8/9 and prostate glands "*unprovided with a terminal copulatory dilatation* (sic)"].

Metaphire sandvicensis: Sims & Easton, 1972: 239 [*javanica*-group with spermathecal pores in 7/8/9].

Perichaeta sandivicensis : lapsus Reynolds & Cook, 1976: 167.

Diagnosis: With two pairs of spermathecal pores in 7/8/9 (Beddard, 1900: 417; sometimes mistakely thought in 6/7/8). No GM. Male pores paired on 18 (not in copulatory pouches - Beddard, 1900: 417). Intestinal caeca simple from 27.

Distribution: Hawaii (Lanai at 2,000 ft, Mauna Loa, Hawaii, Molokai) and China (Hong Kong).

Behaviour: ?

Length: 100.

Width: ?

Segments: 105.

Colour: ?

Prostomium: ?

First dorsal pore: 11/12.

Setae: Numerous, ca. 20-53 per segment, setae enlarged on segments 4-7.

Nephropores: Not found.

Clitellum: Annular in 14-16.

Male pores: "*very prominent*" (everted?) on 18 with about 18 setae intervening.

Female pores: Single on 14.

Spermathecal pores: Two pairs, most likely in 6/7/8.

Genital markings: None.

Septa: 5/6/7 and sometimes 7/8 thick, 8/9-9/10 aborted, 10/1/12 also thickened.

Dorsal blood vessel: Single?

Hearts: Last in 13.

Gizzard: Between septa 7/8 and 9/10.

Calciferous glands: None.

Intestine origin (caeca, typhlosole): Caeca long and slender occupying 2 segments.

Nephridia: Meroic, (?tubules absent from spermathecal ducts).

Male organs: Testes/funnels in testis sacs in 10 and 11; seminal vesicles in 11 and 12.

Ovaries: In 13.

Prostates: Much incised racemose, ducts long and curved claimed without copulatory pouches by Beddard although small pouches were noted by RJB from the syntypes.

Spermathecae: With short duct and short zig-zagging diverticulum.

Gut contents: ?

Remarks: The above description is derived from original combined with later treatments by Michaelsen (1900), Beddard (1900) and Sims & Easton (1972). However, there are conflicts as copulatory pouches are stated to be absent and the spermathecal pores are now known (since Beddard, 1900: 417) to be in 7/8/9 (not in 6/7/8!), and while Sims & Easton (1972) place it in *Metaphire*, which requires copulatory pouches, and in a *javanica*-group, which requires spermathecal pores in 7/8/9, Beddard (1900: 417) said there were no terminal sacs on the prostate glands (i.e., in *Amynthas*). Furthermore, Michaelsen correctly lists Beddard's account as page 203, while Sims & Easton for this reference list only "*pp. 194-201*" (actually Beddard's paper is 194-211). Obviously the status of this species requires resolution, it is included here because it has the wide distribution of a peregrine species and is obviously introduced to Hawaii. Beddard (1896) compared his *sandviciensis* with *Polypheretima annulata* and *Amynthas japonicus* (Horst, 1883) which have spermathecal pores in 7 and 8, and 6/7/8 respectively (see *Polypheretima annulata*). Later, Beddard (1900: 417-419; 1900: 633) combined it with his *hesperidum* (= *M. californica*) as summarized by Chen (1933: 276) thus: spermathecae in 7/8/9, no genital papillae, caeca simple and remarkably small (two segments), prostates large. Earlier, Chen (1931: 137) included *Perichaeta sandvicensis* Beddard, 1896: 203 (along with *Amyntas loehri* Michaelsen, 1899: 12 and *Pheretima kiangensis* Michaelsen, 1931:21) in synonymy of *Pheretima hesperidum* (Beddard, 1892) that is now in synonymy of *Metaphire californica* where these other taxa probably also belong as indeed has now been shown for *M. sandviciensis* – Q.E.D.

Metaphire ryunome Blakemore, 2012.

Fig. 2.20i. *M. ryunome* holotype.

Metaphire ryunome Blakemore, 2012: 145, fig. 10; Blakemore & Lee (2013: 133).

Material inspected: Holotype (H), NMST An457, mature posterior amputee specimen fixed and stored in 80% ethanol (EtOH), here dissected and figured (Fig. 10), collected

2.II.2011 by RJB. Paratype (P) NMST An458, mature complete specimen fixed and stored in 80% EtOH.

Etymology: Japanese "dragon eyes", for the appearance of the male pores.

Diagnosis: Marginally in *Metaphire* with spermathecal pores 0.3 apart in 7/8/9. Genital markings small near or within spermathecal and male pores. Intestinal caeca simple (sometimes serrate) from 27. Spermathecal diverticula elongate. Dorsal pores 10/11.

Distribution: Type locality Japan, Shiga-ken, Hikone (ca. 35°16'N 136°16'E), Kaideima-cho, from 'aze' (dividing pathway) adjacently to Shiga Uni rice paddy plots. Also from Busan (Blakemore & Lee, 2013) and, from Genbank data, from China!

Description: Length 30+mm (H) and 45 mm with 70 segments (P). Dorsum a faint brown colour with no mid-dorsal line, clitellum darker and ventrum pale. Dorsal pores from 10/11. Setae ca. 60 per segment. Spermathecal pores ca. 0.3 circumference apart in 7/8/9. Genital markings absent or as small discs just posterior to spermathecal pores in 7/8 and 8/9 (absent from 7/8rhs on H); small papillae internal to eye-like secondary male pores on 18 just median to primary male pore within small hollow construed as strictly non-superficial thereby just qualifying for *Metaphire*.

Internally, small stalked glands correspond to the external genital markings. Peptonephridia to 5/6, septa after this thin, 8/9 present (at least ventrally) going to base of gizzard, 9/10 absent, 10/11/12 slightly thickened. Nephridia meroic forests. Spermathecae in 8 and 9 each having spherical ampulla on short duct with elongate diverticulum (inseminated). Dorsal vessel single; hearts in 10-13. Holandric, testis in sacs in 10 & 11; seminal vesicles anteriorly in 11 & 12. Ovaries fan-shaped with funnels in 13; no ovisacs in 14. Prostate racemose on long muscular ducts. Oesophagus not dilated; intestinal origin in 16 with simple, smooth (or slightly serrate) caeca from 27. Typhlosole and gut contents not recorded. Parasites not found.

mtDNA COI-5P Barcode result:

Metaphire ryunome Holotype (H) An457 from Hikone.

BOLD Systems (www.boldsystems.org/) data for holotype tagged An457.1 (compared to sub-samples An457.2 and to paratype (P) An458.1 and An458.2 all initially tagged as "*Metaphire robustus*" from preliminary identfication by RJB).

AACTCTATACTTTATTTTAGGAATTTGAGCCGGAATAATCGGAGCTGGGATAA
GCCTACTTATCCGCATTGAACTAAGTCAACCGGGGTCTTTCCTTGGAAGAGA
CCAGTTATATAATACGATTGTAACAGCACATGCATTCCTCATAATTTTCTTCTTA

GTAATACCAGTATTTATTGGGGGGTTCGGAAACTGGTTGCTACCACTAATACT
AGGAACACCAGATATAGCATTCCCCCGACTAAATAACATAAGATTTTGACTAC
TCCCCCCTTCCCTAATTCTCCTAGTGAGATCAGCTGCCGTAGAAAAAGGAGC
AGGTACAGGTTGAACAGTATACCCACCCCTAGCAAGAAATATAGCACATGCG
GGCCCCTCAGTAGATCTTGCAATCTTCTCACTACATTTAGCAGGTGCCTCGTC
AATTTTAGGAGCTATTAATTTTATTACCACAGTGATCAATATACGATGGTCAGG
ACTACGACTAGAACGAATTCCATTATTTGTTTGAGCAGTAATAATTACTGTAGT
ACTACTACTATTATCACTCCCTGTACTAGCCGGTGCAATTACTATACTACTAAC
AGACCGAAATCTTAACACATCCTTCTTTGATCCAGCTGGTGGTGGAGACCCA
ATTCTATACCAACACTTATTC

BLASTn and megaBLAST analyses:

An457.1 vs. An457.2 vs. An458.1 vs. An458.2 = 100% , i.e. specimens same species.

An457.1 match with *A.tralfamadore* type is no better than 85%, i.e. different species.

megaBLAST of An457.1 was 99% similar to "*Amynthas incongruus*" voucher EF077552 from China; and 85% matches with "*Amynthas tristriatus*" voucher EF077538 from China, or with "*Amynthas robustus*" vouchers DQ224191 and AB542533 from Taiwan and Japan, respectively (similar to *A. tralfamadore* result).

Remarks: Although coming closest to the restricted definitions of either *A. masatakae* or *A. robustus* the most noticeable differences are lack of markings either mid-ventrally in 18 or paired near spermathecal and/or male pores, respectively. On the basis of the morphology differing from the types of *A. robustus* or *A. masatakae*, and because the mtDNA COI barcodes differ from what workers in Japan and Taiwan label as "*A. robustus*" (including *masatakae*?) these Hikone specimens were thus newly named. However, it is entirely possible that the COI vouchers from Japan and Taiwan represent some other valid or invalid synonyms of *A. robustus*, as is detailed herein.

Metaphire ryunome is morphologically comparable to Kobayashi's (1937) Korean "*masatakae*" and to *Pheretima reisuiensis* Kobayashi, 1938: 139 from "Zenra-nan-dô" (= South Cholla) that too has spermathecal pores in 7/8/9; however, its anterior markings are more median in intersegmental furrows, amongst many other differences such as its dorsal pores from 11/12 and setae numbering 25-60. Kobayashi (1938) figures and describes "*Secondary male pore represented as a large eye-like aperture*" within which the primary male porophore is found. On the basis of this, it qualifies for genus *Metaphire* in a new combination as *M. reisuiensis*.

Possibly both species are transitional from *Amynthas* Kinberg, 1867 to *Metaphire*

Sims & Easton, 1972, the former having superficial male pores and often complex genital markings, the latter often with intromittent organs in "copulatory pouches" of various depths thus having less need of genital markings to adhere, attach and help co-locate superficial pores of concopulants.

Busan specimen differed slightly (Blakemore Lee, 2013), nevertheless DNA showed 100% conformity with barcode results in Blakemore (2012). Finding *M. ryunome* in Shiga, Japan, now Busan, Korea and China indicates that this species has wide distribution suggesting it is peregrine and is to be expected from other countries. DNA data shows it closest to Chinese "*A. incongruous*" on GenBank; however, that taxon typically has spermathecal pores in 5/6/7 rather than 6/7/8 and a different arrangement of GMs, at least, compared to those discussed by Blakemore (2012) for *M. ryunome*. Most likely the identity of the Chinese specimen was mistaken, just as the DNA data for *A. masatakae* appears misidentified with Chinese *A. triastriatus* (Chen, 1946) on GenBank. [See also *A. tralfamadore*].

?*Metaphire tschiliensis tschiliensis* (Michaelsen, 1928)

?*Amyntas asiaticus* Michaelsen, 1903: 11 (part.). [Tibet border. Types in Moscow].

Pheretima asiatica : Gates, 1939: 494; 1958: 28 [?syns. *tschiliensis* (priority! although this is probably just Gates' ridiculous methodology), *praepinguis*].

Pheretima tschiliensis Michaelsen, 1928: 13. [From Chihli, Northern China (= Zhili an historical state next to Inner Mongolia). Type Hamburg 10519, although Gates (1939: 488) says they are in Stockholm then goes on to describe Hamburg "V 10579" - 2 softened specimens that he says are the types]; Chen, 1933; 1936 (syns. *kiangsuensis, grahami, praepinguis*); 1956: 8, fig. 7 (?syn. or similar to *praepinguis, guillelmi*); Gates, 1939: 488 (syn. *kiangsuensis, asiatica* part?, *tibetana*, ?*yamadai*).

Amynthas tschiliensis : Sims & Easton, 1972; Tsai, 2000.

?*Metaphire tschiliensis tschiliensis* : Tsai *et al.* , 2003; Blakemore, 2007; Chang, 2008.

Pheretima kiangsuensis Chen, 1930. [Types?]. [Synonymy from Chen (1931; 1933: 250)] (non *Ph. kiangensis* Michaelsen, 1931)].

?*Pheretima grahami* Gates, 1935: 9. [Types US 20093]; Gates, 1939: 437 [synonymy from Chen (1936: 298, 302) cf. Gates (1939: 439) who says the deep

spermathecal pores clearly separate *grahami* ; and cf. Chen *et al.* (1977: 22) where *grahami* appears maintained as a sub-species of *tschiliensis*)].

Pheretima praepinguis Gates, 1935: 15. [Types US 20106]; Gates, 1939: 471; 1958: 28 [synonymy from Chen (1936: 298, 302); cf. Qiu & Bouché (1998: 86) who mention a subspecies *Metaphire praepinguis jiangkouensis* Qiu & Wang, 1993].

Notes: Name sometimes misspelt and misdated as "*tsiliensis* Michaelsen, 1938" and misspelt "*tischiliensis*" on BIOSIS ION website. Subspecies possibilities are:

?***M. tschiliensis grahami*** (Gates, 1935: 9) from Szechuan (and Vietnam?).

M. tschiilensis kokoana (Chen & Fang, 1975: 94) from China – see below.

?***M. tschiilensis lanzhouensis*** (Feng, 1984: 47) from China.

?***M. praepinguis jiangkouensis*** Qiu & Wang, 1993 from China?

Diagnosis: Spermathecal pores small, superficial widely separated in 6/7/8/9 (cf. insunk in large transverse slits in 6/7/8/9 in *grahami, praepinguis*), male pores on 18 in circular insunk pouches (if thus, then in *Metaphire*), both sets of pores with genital papillae internally (or the pores shown by Chen to be large puckered, sucker-like discs with superficial male pores towards outer edge of disc near a small papilla. Gates (1958) describes Omei 'giants' up to 470 mm by 17 mm with up to 154 segments; but 'normal' populations are smaller 110-330 mm. Grey-brown pigmentation. 1st dorsal pore functional in 13/14. Intestinal caeca simple incised. Specimens often parasitized and abnormal (Gates).

Distribution: North and Central China, (Vietnam?), claimed from northern peninsular Malaysia (Ref., 2013, ID based only on DNA by Huang et al. 2007).

Remarks: All three synonyms above were put in *Metaphire* by Sims & Easton (1972), whereas *tschiliensis* was put in *Amynthas* – see Blakemore (2007). Gates (1939) described *grahami, praepinguis* and *tschiliensis* separately, often from types, and (p. 494) said poorly-described *P. tibetana* may be a synonym of *tschiliensis* or of *guillelmi*.

At one time (Gates, 1935: 1218) thought, *A. obscuritoporus* (Chen, 1930) and *M. tibetana* (Michaelsen, 1931) should be united with *P. tschiliensis*; later Gates (1958: 28) combined *P. asiatica* (Michaelsen, 1900) under *P. tschiliensis* Michaelsen, 1928, although *asiatica* has priority. Subspecies *Amynthas tschiliensis kokoanus* (Chen & Fang, 1975: 94) was moved to an *A. sieboldi* species-group of Sims & Easton (1972) [= *Metaphire sieboldi* group by Blakemore, 2003 and repaced by *Amynthas carinensis* (Rosa, 1890) group by Blakemore (2014)] by Easton (1979: 120) but is possibly better placed as *Metaphire kokoana*.

M. yamadai (Hatai, 1930) is almost exactly similar superficially to *M. aggera* (Kobayashi, 1934) that differs in its simple but incised intestinal caeca (?unless these were misdiagnosed in *M. yamadai*), and Kobayashi (1938a: 155, 157) says that his *P. aggera* is close to, and may be synonymous with, ?*Metaphire tschiliensis* (Michaelsen, 1928) and with his own *Metaphire quelparta* (Kobayashi, 1937). *P. praepinguis* had paired presetal markings on 7,8,9 and was said by Gates (1935) to differ from *tschiliensis* by these, but Gates (1958: 28) combined them. *M. trutina* Tsai *et al.*, 2003 from Taiwan is also similar.

Recent molecular work from Chinese/Taiwan studies needs yet to be extended (Ref1, Ref2); however, in no study thus far were types used, consequently the results, conclusions and discussion do little to help resolve taxonomic uncertainty.

Pheretima tschiliensis kokoana (Chen & Fong, 1975: 94).

Diagnosis: Medium-sized. L. 107-160 mm, D. 5.5-8.0mm. Clitellum, prostomium, etc. as in the typical form. Setae also similar in character, 47-68/8, 52-66/21, formula: 19-32 (8), 13-20 (18). A shallow pouch present with 1-4 small papillae in it (fig. 7, B-G). Spermathecal pores nearlly 1/2 of body circumference apart, each borded anteriorly and posteriorly by glandular lips (A-D). Septa, caeca, testis sacs etc. identical with those of *typica*. From China.

Genus ***Pheretima*** Kinberg, 1867 *sensu stricto*

Pheretima Kinberg, 1867: 97, 102; (part) Michaelsen, 1900: 195; Sims & Easton, 1972.

Note: Some authors have date as Kinberg (1866) but Michaelsen (1900: 234) has "*Kinberg, 1867 (66?)*" and Sims & Easton (1972) have "*Kinberg, 1867*".

Etymology: Pheretima or Pheretime (Greek: η Φερετίμη, 6th century BC) was the wife of Cyrenaean King Battus the Lame, she laid siege to a Lybian city and ordered the men crucified, their wives' breasts to be cut off and others to be made slaves of the Persians; later in Egypt, she contracted a contagious skin disease and Herodotus tell us "*Her body swarmed with worms, which ate her flesh while she was still alive. Thus do men, by over-harsh punishments, draw down upon themselves the anger of the gods*" (wiki).

Type-species: *Pheretima montana* Kinberg, 1867: 102, original designation by Michaelsen (1907: 164) [non Michaelsen's (1934: 12) improper designation of *californica* – see Sims & Easton (1971: 178, 219). Note that from this improper designation Reynolds & Cook (1976: 58) mistakenly list type as *P. californica*].

Diagnosis: Megascolecidae with oesophageal gizzard after 7/8, intestinal caeca near 27. Setae perichaetine. Clitellum 14-16. Male pores in copulatory pouches. Spermathecae paired, rarely single. Nephridia meroic with tubules always present on the spermathecal ducts.

Distribution: The Malaysian sub-region to New Guinea. Some species peregrine. Synonymy of *Pheretima (Parapheretima) koellikeri* (Michaelsen, 1928) with *Metaphire vesiculata* (Goto & Hatai, 1899) had removed this genus from the Japanese list (see Blakemore, 2003) although Sims & Easton (1972: 221) thought it introduced. Since nephridia have are unreported from its spermathcal ducts, it is held in *Metaphire*.

Remarks: Only species complying with the characteristics of the type-species, i.e., having copulatory pouches and nephridia on the spermathecal ducts, are placed under *Pheretima*. The generic allocation of degraded morphs lacking spermathecae and/or male pores, especially some currently attributed to '*Pheretima*', *Amynthas,* or *Metaphire*, cannot easily be determined. Sims (1983: 468) said that revisionary studies on the Asio-Australasian megascolecid genus *Pheretima* auct. by Sims and Easton (1972) and Easton (1979, 1984) wrought long overdue name changes and assigned species to eight different genera. This huge taxon had contained nearly eight hundred nominal species of which Sims (1983) regarded less than half as valid. Today the number again approaches ca. 934 valid species (from ca. 1,400 nominal

taxa), but not all synonymies are yet determined. Some less informed authors continue to allocate new taxa to *Pheretima* although *Amynthas* (et *Amyntas*) has strict priority as "*page or position precedence*" (ICZN, 1999: 69A.10) as validated by first revisors. Kinberg (1867) spelt the genus name *Amynthas* (p. 97) and *Amyntas* (p. 101); the former spelling has priority and the second name was preoccupied by *Amyntas* Wollaston, 1865 (Coleoptera), whereas Kinberg (1867) described *Pheretima* on p. 102.

Two sub-genera are included: Subgenus ***Pheretima*** Kinberg, 1867 with type-species *Pheretima (Pheretima) montana* (Kinberg, 1867) from Tahiti; and subgenus ***Parapheretima*** Cognetti, 1912: 556 with type-species *Pheretima (Parapheretima) aberrans* (Cognetti, 1911) from New Guinea. [Note: An Australian Museum registration, W.197360, for *P. aberrans* from "*Bulli, NSW*", is actually from Bulli, Papua New Guinea (RJB pers. obs.)]. These two subgenera are separated on absence or presence of secretory diverticula on the copulatory pouches, and are distributed in Indonesia/Malaysia, and Borneo/New Guinea, respectively.

Note: The long, slender "*penis sheath*" on the copulatory pouch found in *P. montana* (e.g. as figured by Stephenson, 1931: figs. 9-10) is not the same as the "secretory diverticulum" that characterizes species of the subgenus *Parapheretima*. Neither do the "stalked glands" that are sometimes found on the copulatory pouches of at least one species of subgenus *Pheretima* and are a feature of *Metaphire*, qualify for the subgenus *Parapheretima* (see Sims & Easton, 1972: fig. 1D and p. 221). Species of *Amynthas* are rarely reported with nephridia on the spermathecal ducts (Sims & Easton, 1972: 211) but are differentiated by absence of copulatory pouches.

The sub-genus *Parapheretima* can be expected to usually have nephridia on spermathecal ducts, but they may be few in number or sometimes lacking; for example, Cognetti (1913: fig. 28) did not show them for *Ph.* (*Pa*.) *pluviosa* and Gates (1948: 149) could not find them on his specimens of *Ph.* (*Pa*.) *beaufortii* Cognetti, 1911.

Key to peregrine *Pheretima* sensu stricto species groups

1. Spermathecal pores 4, or rarely five, pairs of spermathecae in (4/5)5/6-8/9 about 0.2 circumference apart, GMs absent ..... *Pheretima* (*Pheretima*) *darnleiensis*

Spermathecal pores three pairs in 6/7/8/9 ..... *Ph. (Ph.) philippina* (Rosa, 1891: 400, fig. 5 of male organs) from from Cebu, Philippines, and Sumatra

(Bidjey Estate) (Michaelsen, 1903: 98). [Note: Beddard (1895: 395) mistakes this as a 'MICH" species; Sumatra citation is for *M. bindyeyensis* (Mich., 1899) now separate].

Spermathecal pores fewer than three pairs.....2

2. Spermathecla pores paired in 5/6 ..... *Pheretima* (*Pheretima*) *urceolata* (Horst 1893: 322) [syn. *Pheretima baweanensis* Michaelsen, 1924: 389 (sometimes mis-spelt "baweaensis" and dated 1923 or 1925), Gates (1961) also placed *Metaphire ditheca* (Michaelsen, 1928) in synonymy but this disputed by Sims & Easton (1972)]. From Sumatra (type locality); Bawean Island, Java Sea (type locality *Ph. baweanensis*), Seratok Sarawak (Michaelsen, 1928: 50) and Philippines, thus relatively widespread.

Spermathcal pores single or paired in 7/8 or 8/9 3

3. Spermathecal pores paired 4

Spermathecal pores single on one side ..... *Ph. unicystis*

4. Spermathecal pores in 7/8 5

Spermathecal pores in 8/9 ..... *Pheretima (Ph.) racemosa* (Rosa, 1891: 399, fig. 8) - reported from both Borneo and Java originally and by Michaelsen (1916: 16) thus possibly widespread (distinguished by "*racemose*", or trilobed, spermathecal diverticulum; and note that Rosa, 1891, fig. 8 does not show nephridia on spermathecal duct!).

5. Copulatory pouch with coelomic penial sheath ….. *P. montana* spp-group

Copulatory pouch without penial sheath ….. *P. sangirensis* spp-group

Pheretima* (*Pheretima*) *darnleiensis (Fletcher, 1886)

Fig. 2.21a *P. (P.) darnleiensis*, Mt Kinabalu, Borneo. YNU collection, 2003. Figure shows prostomium, spermathecae and prostates in situ, with an enlargement of one spermatheca, plus an intestinal caecum.

Fig. 2.21b *P. (P.) darnleiensis*, Mt Kinabalu, Borneo - larger specimen showing seminal vesicle in 12rhs with distinctive appendix.

Fig. 2.21c *P. (P.) darnleiensis* distribution local map.

Fig. 2.21d *P. (P.) darnleiensis* distribution world map.

[**Synonymy** of *Pheretima darnleiensis* (from Blakemore, in Blakemore *et al.*, 2007c)].

Perichaeta cingulata (part., cf. *A. robustus*); Vaillant, 1868a: 225, 228; Vaillant, 1868b: 146 misidentifications e.g. of Paris AE 687 from Ile de France (Mauritius). [Non *Perichaeta cingulata* Schmarda, 1861: 14, fig. 163 (= *Megascolex cingulatus* from Sri Lanka as redescribed by Beddard, 1892: 122, figs. 9-13; 1895: 382;

Michaelsen, 1900: 229; 1903: 95; Stephenson, 1923: 236, fig. 86)].

Perichaeta indica : Horst, 1885: 4 (syn. *cingulata* : Vaillant, misidentification.) [Non *Megascolex indicus* Horst, 1883: 186 (= *Amynthas corticis* Kinberg, 1867 according to Easton (1981: 49)].

Perichaeta Darnleiensis (sic) Fletcher, 1886/7b: 966. [From Darnley Island, Torres Straits, Australia. Types missing from the Macleay Museum, at the University of Sydney despite recent searches - Dr. Margaret Humphrey, Curator, Entomology pers. comm. to RJB, April, 2005]. [Authorship dated "1886" e.g. by Michaelsen (1900); dated "1887" by Sims & Easton (1972: 239, 260); Easton (1983: 732; 1984: 119). "*The part containing Fletcher's paper was actually published on 17 November 1886*" (M.L. Augee, Editor, *Proc. Linn. Soc. NSW* pers. comm. to RJB, Oct. 2004) although the journal, now pubished online, is clearly dated "1887"! Perhaps the editor was refering to Fletcher's earlier paper?].

Perichaeta vaillanti Beddard, 1890: 66. [From Manila, Luzon, Philippines. Type in British Museum 1904:10:5:173 inspected by Sims & Easton, 1972: 181]; Bedard, 1895a: 422. [Note: Beddard (1895: 421, 422) thought *P.(P.) philippina* (Rosa, 1891) from Sumatra and Cebu, Philippines, similar except for its 3 pairs of spermathcae, and *Amynthas enganensis* (Rosa, 1892) similar except for its longer spermathecal diverticula]; Michaelsen, 1900: 311.

Perichaeta martensi Michaelsen, 1892: 242. [From Banka Island east of Sumatra. Types Berlin: 2148]; Horst, 1893: 324 (from Sumatra); Beddard, 1895a: 416 (?syn. *darnleiensis*); Michaelsen, 1896: 240 (syn. *eoa*).

Amynthas martensi: Michaelsen, 1899b: 87.

Pheretima martensi: Michaelsen, 1900b: 282 (syn. *m. javana, eoa*).

Perichaeta bosschae Horst, 1893: 324,pl. 10, fig. 6. [From Borneo (Baram River, Sambas). Type in Leiden Museum: 1829. Note: fig. 6 of a spermatheca shows a short simple clavate diverticulum, thus possibly a valid and separate speces]; Beddard, 1895a: 432; Michaelsen, 1896: 238; 1900: 256; [the 2 specimens Beddard (1900: 892) mis-identified as *P. bosschae* were given the new name of *Metaphire baruana* (Stephenson, 1942: 209) and was subsequently included in synonymy of *Metaphire malayana* (Beddard, 1900) by Gates (1972: 199). Name misspelt "boschae" by Michaelsen (1896: 238)].

Amyntas bosschae: Beddard, 1900a: 625, cf. Beddard (1900b: 892) misidentification.

Pheretima bosschae: Michaelsen, 1900b: 256.

Perichaeta martensi javana Michaelsen, 1894: 99. [From Java. Types missing]; Sims & Easton, 1972: 260) [they misspelt Michaelsen's *martensi javana* as "*javanica*"; non *Rhodopis javanica* Kinberg, 1867 (= *Metaphire javanica*)].

Perichaeta darnleiensis: Beddard, 1895a: 406 (?syn. *P. divergens*).

Perichaeta padasensis Beddard & Fedarb, 1895: 73. [From Merabah, Padas Valley North Borneo. Types in British Museum: 1904:10.5:119-26, 1263-4].

Amyntas padasensis: Beddard, 1900a: 624. [Size 120-280 mm].

?*Perichaeta atheca* Rosa, 1896a: 520. [From Sumatra (Balighe, Si-Rambe and Lake Toba). Types in Genoa: 44026-28-33]; Michaelsen, 1900: 254; 1928: 41; Sims & Easton, 1972: 223 [who maintained it as *species incertae sedis* yet noted that Michaelsen (1928: 41) "*regarded it as a subspecies of indica* (= Pheretima (Pheretima) darnleiensis)"]. [Also from Lundu, W. Sarawak by Michaelsen (1928: 41)].

Perichaeta eoa Rosa, 1896a: 528; Rosa, 1896b: 609. [Types Genoa and Turin, Italy].

Perichaeta floweri Benham 1897: 217. [From Bukit Timah, Singapore. Types British Museum 1896.9.30.9-11; these three softened syntypes inspected by Gates (1934: 258) and Sims & Easton (1972: 180)]. [Spermathecal pores in 5/6/7/8/9; setae 35-45 and male pores superfical according to Michaelsen (1900: 267) but which were "*doubtless*" copulatory chambers according to Gates (1934: 259) in his inspection of syntypes where he also noted the "*finger-like*" ampullae of the seminal vesicles (see description under *Pheretima floweri* below)].

Pheretima floweri: Michaelsen, 1900b: 267; *Pheretima floweri*: Gates, 1934: 258; [Gates, 1934: 258 inspected the three macerated British Museum syntypes with this label "*Perichaeta floweri. [18]96.9.30 9-11. Bukit Timah, Singapore. S. S. Flower*": one specimen was useless and was discarded, his redescription was based on the external characters of an undissected specimen and the internal characters of both remaining specimens which were rather shapeless].

Perichaeta madelinae Benham 1897: 219. [From Mt Kinabalu, North Borneo. Types in British Museum 1896:9:30:4]. [Described by Michaelsen (1899: 76; 1900: 291) as *Amyntas* or *Pheretima padasensis madelinae* (Benham)].

Perichaeta belli Rosa 1898a: 286. [From Mindoro, Philippines. Type in British Museum 1898:10:28.5].

Pheretima belli: Michaelsen, 1900b: 255.

Megascolex cingulatus: (part cf. *A. robustus*) Vaillant, 1889: 72.

Amyntas padasensis lokonensis Michaelsen, 1899b: 74. [From Lokon-Gipfel, Tomohon, North Celebes. Type in Basel Museum]. [Miscited by Beddard (1900a: 615) as page "78". Differs from *madelinae* by smaller size (ca. 45-68mm) and having fewer setae (ca. 36)].

Amyntas padasensis madelinae: Michaelsen, 1899b: 76. [Differs from *lokonensis* by larger size (ca. 135mm) and having greater setae (ca. 58). Note: Reynolds & Cook (1976: 132) miscite this as Michaelsen's species as well as Benham's].

Amyntas padasensis padasensis: Michaelsen, 1899b: 74. [Cited by Michaelsen (1900: 290) as *P. padasensis* (*typica*) and differentiated from its sub-species by size >200 mm (ca. 280mm) and having extra seminal vesicles in segment 13].

Amyntas cingulatus: Vaillant (in part); Beddard, 1900a: 615 [miscited by Sims & Easton (1972: 261) as page "625"]; [Syn. *darnleiensis, vaillanti, martensi, indica* Horst, *eoa, madelinae, padasensis* var. *lokonensis, belli*; also in a footnote Beddard (1900a: 615) says that *Perichaeta cingulata* of Schmarda is of course a *Megascolex* as then defined; note, he gives size range as "45-180 mm"]; Beddard, 1900b: 892 [syn: *indica* (part)*, darneleiensis, vaillanti, martensi martensi, m. javana, eoa, madelinae, belli, padasensis lokonensis*). Many of these synonyms were accepted by Sims & Easton (1972) who, however, also add *padasensis* and *bosschae*].

Amyntas peregrinus (?part. inc. *floweri*): Beddard, 1900a: 644; 1900b: 414 (syn. *molokaiensis, floweri*).

Pheretima darnleyensis (sic, illegal emend. corr. *darnleiensis*): Michaelsen, 1900b: 263.

Pheretima indica (part.): Michaelsen, 1900b: 275 (syns. *?corticis, diffringens, ungulata* (laps. pro *cingulata*) *heterochaeta* and *nipponica*); Michaelsen, 1910a: 260; Michaelsen, 1922: 41 (syn. *kuchingensis*); Michaelsen, 1923: 2; Michaelsen, 1928a: 40 (part inc. *indica typica* = *padasensis*); Stephenson, 1930b: 1; 1931b: 273; Michaelsen, 1932a: 614; ?Stephenson, 1932a: 47; 1932b: 219; Ude, 1932: 147 (part inc. *typica*); Michaelsen, 1935: 108; Gates, 1935b: 82, 83 (syn. *floweri*), 94; Gates, 1936c: 389 (syn. *quadragenaria* (part) s. Michaelsen, 1924); Gates, 1937a: 320; Gates, 1937d: 193; Gates, 1940: 413; Gates, 1949: 26. [Note: Gates (1935b) is refering to a later concept of "*P. indica* (Horst), 1883" that Gates certainly re-describes as being *P. darnleiensis* (i.e., not as *indica* (= *A. corticis*)].

Pheretima padasensis typica: Michaelsen, 1900b: 290.

Pheretima padasensis lokonensis: Michaelsen, 1900b: 290.

Pheretima padasensis madelinae: Michaelsen, 1900b: 291.

Pheretima vaillanti: Michaelsen, 1900b: 311.

Pheretima decipiens Beddard, 1912: 180. [Beddard said this species, which he described lengthily but poorly, seems to be "*exactly like* P. banguetensis", he failed to give any convincing argument for their separation and, moreover, since *P. banguetensis* was listed in synonymy of *P. darnleiensis* by Sims & Easton (1972) then too *P. decipiens* most probably belongs. One specimen (of how many?) had only three pairs of spermathcae]. From Luzon, Philippines. Types in London?

Pheretima benguetensis Beddard, 1912: 183, fig. 1. [From 1,524m in the Province of Benguet, Luzon, Philippines. Types ?]. [This name was provisionally maintained separately in Blakemore's (2004b: 133) checklist because it was erroneously listed in a publication by Nakamura (1999: 27) as having only two pairs of spermathecal pores in 6/7/8 - this now known to be a fabrication cf. Beddard's original description. Length to 190mm].

Pheretima kuchingensis Stephenson, 1916: 337. [Type in Calcutta: 6539].

Pheretima quadragenaria (part): Michaelsen, 1924b: 391. [Note: Perrier's species, *P. quadragenaria* Perrier, 1872: 122 with types from East India in Paris (AE 673-4), was originally described with only one pair of spermathecae in 7/8; it is often compared or combined with *P. capensis* at least in part].

Pheretima borneoensis Ude, 1925 [Types British Museum 1933:10:6:26]; Michaelsen, 1928b: 55 (syn. ?*bosschae*); Ude, 1932: 131; Michaelsen, 1934b: 45.

Pheretima indica birangi Michaelsen, 1928b: 42. [Types missing].

Pheretima padasensis: Kobayashi, 1941: 397, fig. 3. [From Caroline Isls.].

Pheretima (*Pheretima*) *darnleiensis*: Sims & Easton, 1972: 260 [syn. *vaillanti*, *martensi*, *m. javanica* [lapsus pro. *javana*], *bosschae*, *padasensis*, *p. lokonensis*, *p. madelinae*, *eoa*, *floweri*, *madelinae*, *belli*, *kuchinensis*, *quadragenaria* (part), *benguetensis*, *borneoensis*, *indica birangi*]; Easton, 1982: 732; Easton, 1984: 119 (syn. *indica*: Gates, 1937: 320); Blakemore, 1994: 368; 2002: 216; Blakemore in Blakemore *et al.*, 2007c (syns. as above, i.e. following Sims & Easton but revising their errors and omissions with latest findings and including *Pheretima decipiens* Beddard, 1912: 180 as **syn. nov**). [Cf. Hong & James, 2010, as parroted by James (pers. com. April, 2011) who appears to repeat these synonyms but complains undeservedly about the size range being too wide, as

was stated exactly by Blakemore (2007): this being due entirely to Sims & Easton's unresolved revision! Nevertheless these latter authors, rather than make an effort to thoroughly revise, simply add yet more synonyms (below) to the bloated and unresolved list.

Pheretima pugnatoris Hong & James, 2010. From Philippines. **Syn. nov.**

Pheretima tabukensis Hong & James, 2010. From Philippines. **Syn. nov.**

Pheretima barligensis Hong & James, 2011. From Philippines. **Syn. nov.**

Note 1: The latter three species names are added to the *P. darnleiensis* species group synonymy as their authors made no attempt to unravel the complexities of *P. darnleiensis* as outlined by Blakemore *et al.* (2007: 40) where it was clearly stated:

"*Despite these revisions, the current paper presents just the* status quo *as full resolution of the status, extent, and synonymy of* Pheretima darnleiensis *proper primarily depends on exact delimitation of this taxon, either by discovery of its missing type(s), or by neotypification, preferably on a specimen from the Darnley Island type-locality. Only then can progressive, serial and chronological delimitation of its synonyms commence, again using their types, and possibly employing molecular (DNA) and behavioural identification methods*."

Rather than seeking to redescribe any of the earlier synonyms listed above, they just added to the complexity and 'promise' to work it out later – as I could have done by giving my Borneo material, and every other specimen I find, a new name. But, unlike some authors, I am not paid to waste other peoples' valuable time nor to irresponsibly mislead future students. Despite their high talk and empty words, the authors of the latter three names cannot differentiate from current concepts of *P. darnleiensis* and do not even provide DNA barcodes from their types, presumably leaving this for someone else to fix at some other time while cynically taking credit for two "new" names... This is again reminiscent of the *Amynthas carnosus* and the *Pheretima urceolata* débâcles. Almost 100 years ago Beddard (1912: 180) commented on the source of some of this taxonomic confusion with *P. darnleiensis*; these latter authors would do well to read this too as a starting point for their Philippine studies which seem to be stung out in as series of inconclusive and unresolved "Calendar Papers".

Note 2: A fuller synonymy is presented above because of confusion since Beddard (1900: 615, 625) and Michaelsen (1900: 275) wrongly applied through

misidentification the names *Perichaeta cingulata* Schmarda, 1861 [= *Megascolex cingulatus* from Beddard (1892: 122)] and *Megascolex indicus* Horst, 1883 (= *Amynthas corticis*) respectively, names that Sims & Easton (1972: 264) say are "*invalid*" [but they mean that the later applications of these names were incorrect! - see below] and should thus yield to the next available name which is *P. darnleiensis* Fletcher, 1886/7. Identification of *Perichaeta cingulata* Schmarda, 1861: 14, fig. 162 was also confounded by Vaillant (1867; 1868a, b) who confused several 'good' *Pheretima* species under this name (e.g. *robustus*, *darnleiensis*, *quadragenaria*); it is actually *Megascolex cingulatus* (Schmarda, 1861) from Sri Lanka – as redefined by Beddard (1892b: 122; 135, figs. 9-13) from inspection of two specimens in the Vienna Museum [#3959] one of which was the type of Schmarda's "*Perichaeta cingulata*". [Note that Reynolds & Cook (1976: 88) mistakenly cite Schmarda's types in the Paris Museum; and list Beddard's 1982 redescription (of the Vienna type) as a new and valid name]. Whereas the taxon *Amynthas indicus indicus* (Horst, 1883: 186), as listed by Sims & Easton (1972: 235) who tended to repeat all names irrespective of synonymies, has now been placed under *A. corticis* (Kinberg, 1867), e.g. by Easton (1981: 49) and by Sims & Gerard (1985; 1999: 128, fig. 45). Note: Easton (1982: 732) mistakes "*Fletcher (1887)*" for Fletcher (1886).

Note 3: The *P. darnleiensis* synonymy above largely follows Sims & Easton (1972: 260-264, 266) who give a full distribution, discussion and descriptions of types and of their material. However, the following account is emended slightly, being compiled from various sources listed in the synonymy above and from new material inspected by the current author as presented below.

Note 4: Reports of several similar taxa are claimed from various regions (e.g. Taiwan, Singapore, or Philippines) but their correct identity will depend of full and thorough revision of (type series of) **all** synonyms and similar taxa, otherwise most new names will perforce be further synonyms of the prior *P. darnleiensis* (as for Note 1 above).

Diagnosis: *Pheretima* with (three?), four, or rarely five, pairs of spermathecae in (4/5) 5/6-8/9 about 0.2 circumference apart ventrally. Male on 18 ca. 0.2 circumference apart in slit-like copulatory pouches. Lacking genital markings. Caeca in or near 27, simple or with complex margins.

Distribution: The tropical Indo-Australasian Archipelago and islands: Malaysia (e.g. Fraser's Hill and Johore -Stephenson, 1932), Singapore, Berhala Island to east of Malay Peninsula, Borneo, Indonesian Islands: e.g. Sumatra, Java, Bali; Christmas Island south

of Java [Australian Territory, by Michaelsen (1935a) and Gates (1935b: 94)], Philippines, North Celebes, Moluccas, Caroline Islands, Fiji and Darnley Island in the Torres Straits - after which it was named but unlikely to be its origin. Sims & Easton (1972: 263) dismiss reports from Sri Lanka and South Africa, and Easton (1982: 732) thought that records from Darnley, Caroline, Kei, and Fiji islands (at least?) were the result of introductions. Hawaiian reports of *Perichaeta indica* Horst are more likely to refer to *Amynthas corticis* than to *P. darnleiensis* proper. It is listed from Brazil [after Knäpper (1972a,b), Righi (1965, 1967c, 1980), Righi and Knäpper (1965, 1966), Chang (1997), Caballero (1973), Sautter *et al*. (2006), Brown *et al.* (2006) reports], but this is unconfirmed and it probably refers to the erroneous *P. indica* report (?= *A. corticis*).

Material examined: Two large mature specimens (dissected and figured by RJB), from Mt Kinabalu, Borneo YNU collection 2003; other specimens collected Mt Kinabalu by a YNU student in 2004 (see Blakemore *et al.*, 2007c). As noted above, attempts to locate the type series in Macleay Museum Sydney were unsuccessful – possibly neotypification from type locality is required for full resolution.

Lengths: Given as 45-280 mm (e.g. in former *padasensis* sub-species – cf. Hong & James, 2010!), cf. 108 mm (Fletcher) and stated to be only 75-170 mm by Sims & Easton (1972) who included just those *padasensis* synonyms (!). Current largest specimens measure 385 and 305 mm, respectively; in life Mt Kinabalu specimens are 400 mm or longer (Schilthuizen, pers. comm.) thus obliging the current author to state the current size range (cf. Hong & James, 2010 who seem confused and offer no summary of these prior taxa – as would normally be required in good Science).

Width: 2.5-6 mm.

Segments: 70-120 [155 by Fletcher; repeated by Beddard (1895: 406)]. Current specimens up to 180 segments.

Colour: Blue-grey or brown.

Prostomium: Open epilobous.

First dorsal pore: 12/13 or less often 11/12.

Setae: Numerous, especially in posterior, ca. 25-66 per segment, no ventral gaps nor crowding. About a dozen setae intervene between male pores. The original description had 60-66 setae per segment (as for *madelinae* and *belli* cf. 35-45 for *floweri*). Current specimens have 60-70 seta in anterior segments.

Nephropores: Not recorded.

Clitellum: Annular 14-16, setae occluded.

Male pores: On 18 ca. 0.2 circumference (3mm) apart in slit-like copulatory pouches with 12 setae between.

Female pores: Single or closely paired on 14.

Spermathecal pores: Usually four, rarely five in (4/5) 5/6-8/9 about 0.2 circumference apart ventrally about in line with 10th setae on each side.

Genital markings: None.

Septa: 4/5-7/8 thickened; 8/9 membranous or absent, 9/10 absent; 10/11+ thickened.

Dorsal blood vessel: Single.

Hearts: Hearts 10-13, supra-oesophageals present.

Gizzard: Between 7/8 or 8/9 and 10/11.

Calciferous glands: Oesophageal pouches absent (dilations in 11 and 13).

Intestine origin (caeca, typhlosole): 15 or 16; caeca simple or with complex margins, paired 26,27-24,22; typhlosole not recorded.

Nephridia: Meroic, tufted in 5-6, also present on spermathecal ducts.

Male organs: Testes/funnels holandric in 10 and 11 in testis sacs, seminal vesicles (each with a finger-like extension) paired in 11 and 12 and sometimes 13; coelomic sacs sometimes present in 12/13 and 13/14 (called pseudovesicles in 13 & 14 by Gates, 1934).

Ovaries: Paired in 13.

Prostates: Large racemose in 17-19, ducts pass into copulatory pouches that each contains a conical penis and an anterior and posterior sectetory pad; the coelomic surface of each pouch has small glandular masses above each secretory pad.

Spermathecae: Paired in (5-9 or) 6-9; small, duct short and stout and coated with nephridial tubules; diverticulum ectal in origin and typically clavate but sometimes with additional (two or three) lobes to its bulb (called "ampulla" by Sims & Easton, 1972: 262) that is equal in length to the stalk (called "duct" by Sims & Easton, 1972: 262).

Remarks: Fletcher (1886b: 967) first reported “testes” in 11 and 12, but later (1887b: 603) corrected these to seminal vesicles. Sims & Easton (1972: 264) found the extra spermathecae only infrequently in a few of their Mt Kinabalu specimens but decided not the give them separate taxonomic status. Variations in the intestinal caeca from typically simple to lobate (e.g. in *borneoensis* or *bosschae*) were correlated with growth of specimens and were not deemed of taxonomic value, and Sims & Easton (1972: 264) also thought the glandular masses on the copulatory pouches were possibly homologous to the secretory diverticula diagnostic of *Parapheretima*. Orginally *padasensis* defined specimens with bi- or tri-lobed spermathecal diverticula but single lobes specimens were

allowed by Michaelsen (1899; 1900) and by Gates (1935: 83).

Sims & Easton (1972: 266) note that hexathecate *Metaphire fordi* (Michaelsen, 1934: 40) may be confused with *P. darnleiensis*, although *fordi* is much slimmer and lacks nephridia on its spermathecal ducts, and *darnleiensis* lacks genital markings. Other similar species are perhaps metandric decathecal *Metapheretima loriae* (Rosa, 1898) from New Guinea, Solomons, and Vanuatu and *M. pickfordi* (Gates, 1959) from Solomons, and Vanuatu both as described by Lee (1981: 554), that however lack intestinal caeca. Holandric octothecal *Metaphire malayana* (Beddard, 1900) [syn. ?*Amyntas pulauensis* Beddard, 1900: 904; ?*Pheretima baruana* Stephenson, 1932; *Pheretima fovella* Gates, 1949: 21; and *Pheretima strellana* Gates, 1949: 34] from Malaya, Thailand and Myanmar as described by Gates (1972: 199), cf. *Amynthas juliani* that has similar genital markings but is perhaps unique in retaining septum 8/9. However, *M. loriae* either has septum 8/9 or lacks it (Lee, 1981: 554). None of these latter species is yet known to have the nephridia on spermathecal ducts diagnostic of *Pheretima*.

Michaelsen (1928b: 40,41) regarded Sumatran *Perichaeta atheca* Rosa, 1896 as a subspecies of *indica* (= *Pheretima* (*Pheretima*) *darnleienis*), although Sims & Easton (1972: 223) listed it as *species incertae sedis* because its lack of spermathecae prevented allocation to either *Metaphire* or *Pheretima*.

Pheretima* (*Pheretima*) *montana Kinberg, 1867

Pheretima montana Kinberg, 1867: 102. [Type locality Taihiti. Type material listed by Reynolds & Cook (1976:140) in Stockholm Museum: 1945 and Hamburg Museum: 8616].

?Perichaeta vitiensis Beddard, 1892: 131. [Locality Viti (Fiji). Type in Vienna Museum]. [Note: possibly in genus *Pithemera* because Beddard (1892b: 131) said the caeca "*appear to belong to segment 24*" cf. *Begemius* and James' genera].

Perichaeta taitensis (part, example 2): Grube, 1867: 36 [non example 1 (= *P. taitensis* Grube, 1866: 180) – see *Amynthas aeruginosus*].

Megascolex taitensis (part): Vaillant, 1889:83 (non Grube, 1866).

Perichaeta novarae Rosa, 1891: 396, fig. 3. [From Tahiti. Types in Vienna?].

Amynthas novarae : Michaelsen, 1899: 17 - where he describes *A. novarae* from "*P. taitensis* (part, second specimen)" with *A. vitiensis* in its synonymy.

Perichaeta malamaniensis Benham, 1891: 316. [Type locality Malamani, Philippines.

Types in Oxford].

Perichaeta arturi (sic) Benham, 1897: 205 (corr. *arthuri*). [Type locality New Britain. Types?].

Pheretima montana arthuri (part, non example B): Michaelsen, 1900: 286; Cognetti, 1914: 257.

Perichaeta zonopora Rosa, 1898: 288. [Type locality unknown. Types in British Museum BMNH 1898:10:28:10-17].

Amyntas montanus: Michaelsen, 1899: 437; Beddard, 1900: 619; Cognetti, 1913: 37.

Pheretima montana: Michaelsen, 1900: 285, 286 [syn. *taitensis* (part), *novarae*, *malamaniensis*, *arturi* (part), *vitiensis*, *zonopora*]; Stephenson, 1931b: 56, figs. 9-11 (syn. *novarae*); Gates, 1937: 324.

Pheretima (*Pheretima*) *montana*: Michaelsen, 1928:8; Sims & Easton, 1972: 178,219 (syn. ?*arturi*); Lee, 1981: 560, tab. 1 (syn. *malamaniensis*); Easton, 1984: 119 (syn. *novarae*, *vitiensis*).

Taxonomic Note: Sims & Easton (1972: 220) redescribed *Pheretima montana* "*from an examination of the holotype, material from Rennell Island also Gates, 1957*." Michaelsen (1900) recognized four sub-species, some given specific status by Sims & Easton (1972: 239) as *Pheretima (Pheretima) montana* Kinberg, 1867; *Ph*. (*Ph*.) *arthuri* (sic) (Benham, 1897); *Ph*. (*Ph*.) *malamaniensis* (Benham, 1891); and *Ph*. (*Ph*.) *zonopora* (Rosa, 1898); which are all now included in synonymy as above. Lee (1981: 560) - on the advice of Easton from inspection of its type – confirmed *malamaniensis* in synonymy of *montana*. Although *Perichaeta vitiensis* has been synonymized in *montana* since Michaelsen (1900) placed it there, nephridia on spermathecal ducts have yet to be demonstrated and it possibly belongs in *Pithemera* (see Remarks below).

The following description is from the literature and inspection of Australian Museum material.

Diagnosis: *Pheretima s. strict.* with one pair of spermathecae in 7/8 about 0.4 circumference apart. GMs absent. Male pores on 18 ca. 0.25 circumference apart in slit-like copulatory pouches. Beddard (1899) described *malamaniensis* and *arthuri* as having eversible penes. Intestinal caeca simple with compound margins originating near 27. Nephridia present on spermathecal ducts. [Having spermathecae in segment 8 rather than 7, and a copulatory pouch with (coelomic) penial sheath, separates the *Ph. montana* group from a *Ph. sangirensis* group of Sims & Easton (1972: 219)- see Remarks below].

Distribution: Widepread in Pacific, viz.:- Tahiti, Upolu, Rennell, Fiji, New Caledonia,

Loyalty Island, Vanuatu (New Hebrides), Ceram Island Indonesia (Cognetti, 1913b); New Guinea, Solomons, Marquesas, Samoa, Henderson island (as *Ph. montana arthuri* by Cognetti, 1914), Tonga and on Niue Island also in the Indonesian Islands (Easton, 1984), and in the Philippines (e.g., Malamani, Daraga on Luzon – Michaelsen, 1903). Michaelsen (1928: 297) says it is from the whole Malayan archipeligo as a peregrine species. [An Australian Museum registration, W.197352, of *P. montana* from "Bulli, NSW" is actually from Bulli, Papua New Guinea, as was W.197360 for *Pheretima* (*Parapheretima*) *aberrans* Cognetti, 1911 - pers. obs.].

Habitat: (From Easton, 1984) forest litter and soil, roots of sugar cane.

Length: 70-135 mm.

Width: 3-5 mm.

Segments: 70-110.

Colour: Uniform dark grey to brown and violet.

Prostomium: Epilobous.

First dorsal pore: 11/12 or 12/13.

Setae: Numerous, 34-44 per segment.

Nephropores: None.

Clitellum: Annular: 14-16, setae occluded.

Male pores: On penes in 18 ca. 0.25 circumference apart in slit-like copulatory pouches.

Female pore: Single on 14.

Spermathecal pores: A single pair in 7/8 about 0.4 circumference apart.

Genital markings: None.

Septa: 4/5-7/8 slightly thickened; 8/9 membranous, 9/10 absent; 10/11+ slight.

Dorsal blood vessel: Not reported

Hearts: Last pair in 13.

Gizzard: Between 7/8 and 9/10.

Calciferous glands : Oesophageal pouches absent.

Intestine origin (caeca, typhlosole): 15; caeca simple with compound margins, paired 27-24,20.

Nephridia: Meroic, present on spermathecal ducts.

Male organs: Testes/funnels holandric in 10 and 11 in testis sacs, seminal vesicles small paired in 11 and 12.

Ovaries: Paired in 13.

Prostates: Large racemose, usually bilobed in 17-19, ducts pass into the ectal end of the

penis sheath of copulatory pouches that each contains a long penis. Glandular pads are present on the interior of the pouch before and behind each penis but are not associated with diverticula nor stalked glands.

Spermathecae: Paired in 8 (in 7 in *arthuri* although opening in 7/8 according to Cognetti, 1914); ampulla small on long thin duct with several flexures with dilated ental region where a short diverticulum attaches. Nephridia present on duct.

Remarks: Beddard's original description of the bithecate *P. vitiensis* was for a metandric species (testis in 11 only, but he perhaps missed those in 10 if enclosed in a testis sac, with seminal vesicles in 11 and 12) with intestinal caeca in an unusual position in segment 24 which, if actually the situation, would place this species within the ambit of *Pithemera* (as described herein). No mention of nephridia on spermathecal ducts was made, a compulsory requirement for placement in *Pheretima* s. strict.

Stephenson (1931b: 56, text-fig. 11) does not describe nor show nephridia on the spermathecal duct in his single New Hebrides (= Vanuatu) specimen of *Pheretima montana* collected by Miss Cheeseman, thus some ambiguity exists on its identity.

Lee (1981: 235) thought that all earthworms of Vanuatu, including *Ph. montana* and *Ph. unicystis*, were introduced by pre-European and European man. Specimens of *Pheretima* (*Pheretima*) *unicystis* Lee, 1981 from Vanuatu are possibly parthenogenetic morphs of *Ph. montana* that have reduced male organs and a single spermatheca each (in one of the three specimens lacking a diverticulum) in 7 with pores to 7/8 on only the rhs. Lee (1981: 562, figs. 26-28) compared ***Pheretima* (*Pheretima*) *unicystis*** with closely similar species and subspecies which qualify for the ***Pheretima* (*Pheretima*) *sangirensis*** species-group of Sims & Easton (1972). Included in this latter species-group were *Ph. ceramensis* Cognetti (1922) from Ceram Moluccas in eastern Indonesia, *Ph. crassicystis* (Michaelsen, 1896) from the northern Celebes, Halmahera, Ternate and adjacent islands [non *Cryptodilus crassicystis* Michaelsen, 1897 from Ceylon], and *Ph. sangirensis* (Michaelsen, 1891) from Sangir, Moluccas [possibly also found by Horst (1893: 318) from Flores and Samoa (Vargo, 1999)]. Initially, *Ph. crassicystis* (Michaelsen, 1896) was divided by into three subspecies: *Ph. crassicystis chica* (Michaelsen, 1896: 207), *Ph. crassicystis crassicystis* (Michaelsen, 1896: 204), and *Ph. crassicystis tobeloensis* (Michaelsen, 1896: 207), but these latter two were combined by Michaelsen (1899: 79; 1900: 301), and all were put as sub-species under *Ph. sangirensis*.

Other species having spermathecal pores in only 7/8 that are potential

synonyms if found to have nephridia on spermathecal ducts are:

- *Metaphire quadragenaria* (Perrier, 1872) (sometimes misspelt "quandragenaria" or "quadrangenaria", although his fig. 69 does not show nephridia on duct) from "*East Indies*" (Paris types AE673-674); possibly a senior synonym of *Megascolex capensis* Horst, 1883: 195 from the Cape of Good Hope, as noted by Michaelsen (1900, 1922) who thought both *capensis* and *quadragenaria* were valid species (cf. *M. javanica*). ***Species inquirenda.***
- *Metaphire pulchra* (Michaelsen, 1892) [sometimes misspelt "*pulcha*", "*pulcher*", or "*pulcra*"] from Daraga, Luzon, Philippines,
- *M. ferion* and *M. weberi* both by (Cognetti, 1913);
- *Pheretima xuongmontis* Thai & Samphon, 1990 from Vietnam.

The first three taxa were listed in an holandric *Metaphire "pulcha* spp-group" (*sic lapsus* for *pulchra*) in Sims & Easton (1972: 239), while *M. weberi* was in a proandric *M. densipapillata*-group.

A summary diagnosis of ***Pheretima* (*Ph.*) *unicystis*** Lee, 1981:-
Length 58-72 mm. Colour slight pale red pigmentaion. Setae 56-76 per segment. One spermathecal pore on rhs at 7/8. Male pore in small copulatory pouches that lack secretory diverticula. Septa 8/9/10 present or absent. Gizzard in 8-9. Oesophageal glands lacking. Caeca paired in 27. Hearts 10-13. Holandric: seminal vesicles in 10, 11. Spermatheca in 7 rhs with nephridia on duct, but in one of three specimens lacking a clavate diverticulum with terminal bulb. From Malekula and Erromanga Isls, Vanuatu, from rotten logs or soil.

For examples of the ***Pheretima* (*Pheretima*) *sangirensis*** species-group of Sims & Easton (1972: 239), see the Remarks after description of *Ph. montana* above.

Pheretima* (*Pheretima*) *urceolata (Horst, 1893)

Perichaeta urceolata Horst, 1893: 322, pl. X, fig. 5. [From "in the Lampongs (Sumatra)". Types, 9 or 10 or 11 of in Leiden – Gates, 1961: 296, 298]; Beddard, 1895: 398, 432; Rosa, 1898: 65.

Amyntas urceolatus : Beddard; 1900: 619.

Pheretima urceolata : Michaelsen, 1900: 311; Gates, 1961: 294.

Pheretima baweanensis Michaelsen, 1924: 389. [Bawean Island, Java Sea. Type in Buitenzorg Museum inspected by Gates, 1940: 409 – see Gates, 1961: 294].

?[*Pheretima* (*Pheretima*) *ditheca* Michaelsen, 1928: 45. [From Birang River, Beran, Borneo. Type possibly in Stockholm. Inclusion in synonymy by Gates, 1961 disputed by Sims & Easton, 1972].

Pheretima (*Pheretima*) *urceolata* : Sims & Easton, 1972 [in an *urceolata* – group]; Blakemore, 2010 (syns. James', 2004 *P. baletei*, *P. bukidnonensis*, *P. heaneyi* and *P. kitangladensis*; *P. simsi* James & Hong, 2004; Hong & James', 2008 *P. abiadai* and *P. nagaensis*; and Hong & James', 2009 *P. batoensis*, *P. bicolensis*, *P. buhiensis*, *P. camarinensis*, *P. doriae*, *P. gorasi* and *P. viracensis* – **all syns. novae.** because these authors failed to discriminate their names from the original types – presumably leaving this for someone else to sort out?).

Diagnosis: Some red/brown pigmentation. Length 66-110 by ca. 4 mm. Segments around 100. Setae around 40-60. Spermathecal pores less that 0.5 U apart in 5/6. Male pores in large couplatory chambers each containing a penis with setae intervening (unless occluded by damage of tumescence). Genital markings absent. Caeca simple, smooth. Septa 9/10 often lacking (Gates, 1961). Spermathecae with short duct with nephridial investment, diverticulum with a seminal chamber about same size as stalk.

Distibution: Lampong, Sumatra and Kupang, Timor; Philippines, Davao Province, Mindanao Island at 6,200 ft. on Mt Apo east slope (Gates, 1961: 298); and some other P.I. locations. The Borneo report (for *ditheca*) is now possibly suspect.

Remarks: Sims & Easton (1972) reject Gates' (1961) synonymy of *ditheca* which, because nephridia are not known on the spermathecal ducts, they place as *Metaphire ditheca* (Michaelsen, 1928) from Birang River and Mt Tibang, Kalimantan, Borneo – see Blakemore (2007, 2008). Their *urceolata* group consisted of just *P. urceolata* (Horst, 1893) and *P. baweanensis* (Michaelsen, 1924) but many, many new (synonymic?) names have been recently added from the Philippines, several of which seem suspect as they are barely separable morphologically and no genetic data appears from their nominal 'types'.

Horst (1893) had compared his species to many other species with only a single pair of spermathecae from the Malay archipelago. It should be noted that in the following synonymy additions, the condition of the types of none of these species were checked by those pair of authors below, and also most previous references were

ignored. For example Hong & James (2009: tab. 1 - on which their whole argument for separtion of their 'new taxa' depends) have "*?*" for both spermathecal and male pore spacing, whereas (Gates, 1961: 298) who inspected types of *P. urceolata*, has these, respectively, as spermathecal pores "*somewhat less than ½C apart*" and copulatory chamber apertures, large transverse slits "*ca. 1 mm. apart*". Synonymy now includes: James', 2004 *P. baletei*, *P. bukidnonensis*, *P. heaneyi* and *P. kitangladensis*; *P. simsi* James & Hong, 2004; Hong & James', 2008 *P. abiadai* and *P. nagaensis*; and Hong & James', 2009 *P. batoensis*, *P. bicolensis*, *P. buhiensis*, *P. camarinensis*, *P. doriae*, *P. gorasi* and *P. viracensis* – **all syns. novae** as noted above**.**

Genus ***Pithemera*** Sims & Easton, 1972

Pithemera Sims & Easton, 1972: 202. [Anagram of 'Pheretima'].

Pithemara (laps.): Gates, 1982: 42.

Type-species: *Perichaeta bicincta* Perrier, 1875.

Diagnosis: Small to medium sized (<130mm) pheretimoids. Perichaetine. Clitellum annular, 14-16. Male pores superficial on 18. Female pores usually unpaired on 14. Gizzard present between 7/8 and 9/10. Oesophageal pouches absent. Intestinal caeca single midventral in 21 or 22 or paired laterally originating in or near 22 (or 23), or, rarely, 24. Spermathecae (one, or) two or more pairs in segments 5-9.

Taxonomic Note: The diagnosis of Sims & Easton (1972: 202) is emended to allow an intestinal caecum in 21 (as in *P. ablata*) or caeca in 23 or 24 (if *buentei*, *sempoensis* , and *vitiensis* are included) and to permit fewer than three pairs of spermathecae (e.g. two pairs in *ablata*; one pair in *vitiensis*).

Distribution: Pacific isles in Solomons, New Britain, Fiji, Samoa, Vanuatu and (*sempoensis*) from Korea. New (endemic) species have recently been described from Philippines (James *et al.*, 2004 and Hong *et al.*, 2005) and from Taiwan [viz. *Pithemera lanyuensis* Shen & Tsai, 2002 that is close to *Pi. bicincta*]. Only the type-species has been widely reported outside this region.

Remarks: Allocations by Sims & Easton (1972) and revisions by Easton (1979: 120) produced these components: The *Pithemera bicincta*-group comprises *Pi. bicincta* (Perrier, 1875), and its possible synonyms *Pi. violacea* (Beddard, 1895) and *P. aimerikiensis* (Ohfuchi, 1941). The *Pithemera pacifica*-group is for metandric species with spermathecae in 5/6/7/8/9 and includes *Pi. dahli* (Ude, 1905); *Pi. pacifica* (Beddard, 1899) and (according to Ude, 1932) its junior synonym *Pi. bipapillata* (Ude, 1905) [non Chen, 1936 (= *Metaphire bucculenta* Gates, 1935)]; and possibly if it is not an *Amynthas* also the holandric *Pheretima liangi* Michaelsen, 1922 (see Easton, 1979: 119). The *Pithemera sedgwicki*-group was characterized by a single mid-ventral caecum and comprises: *Pi. sedgwicki* (Benham, 1897) and its sub-species *Pi. s. cognettii* (Ude, 1932); *Pi. ablata* (Ude, 1932) [doubtfully a junior synonym of *Amyntas godeffroyi* Michaelsen, 1899]; and *Pi. mira* (Gates, 1972). Other included species are *Pithemera eldoni* (Gates 1975), *Pi. palaoensis* (Ohfuchi, 1941), and *Pi. sempoensis* (Kobayashi, 1938).

'*Pheretima' vitiensis* (Beddard, 1892) should probably be added as a new combination in *Pithemera* as it was originally described with paired intestinal caeca in 24 (complying with Sims & Easton's diagnosis of *Pithemera*), also it has a single pair of spermathecal pores in 7/8, and metandry, albeit this species has remained in the synonymy of *Pheretima montana* since Michaelsen (1900).

Partial Revised Key to Pithemera *

1. Intestinal caecum single, mid-ventral in 21 or 22 (*sedgwicki*-group) ……... 2
   Intestinal caeca paired lateral, originating in 22-24 …….. 3
2. Spermathecae three pairs in 5/6/7/8 …. *P. sedgwicki sedgwicki* (Benham, 1897) and its sub-species *P. s. cognettii* (Ude, 1932)
   Spermathecae two pairs in 6/7/8 …….. *Pithemera ablata* (Ude, 1905), [cf. ?*Amynthas godeffroyi* (Michaelsen, 1899)]
3. Five thecal segments, first spermathecal pore at 4/5 (*bicincta*- group) …..…..… 4
   Four or three thecal segments, first spermathecal pore at 5/6 ……..… 5
   Spermathecae one pair in 7/8…….. ?*Pheretima vitiensis* (Beddard, 1892)
4. Only slightly pigmented, pale brown anterior …. *Pithemera bicincta* (Perrier, 1875)
   Dark red/claret pigmentation …….. *Pithemera violacea* (Beddard, 1895)
5. Four thecal segmgments (*pacifica*-group) …….. 6
   Three thecal segments (5/6/7/8) …. *Pithemera sempoensis* (Kobayashi, 1938)
6. Holandric (testis in 10 and 11) …. *Pithemera liangi* (Michaelsen, 1922) [but possibly *Amynthas diffringens* (= *A. corticis*) spp-group – see Easton (1979: 119)].
   Metandric (testis in 11 only) ……. *Pithemera pacifica*-group comprising *P. dahli* (Ude, 1905); and *P. pacifica* (Beddard, 1899) including its junior synonym *P. bipapillata* (Ude, 1905) [non Chen, 1936 (= *Metaphire bipapillata*)].

*Sims & Easton (1972: 203) provisionally excluded *Pheretima buentei* Ude, 1924 as it shared many characters with species of *Pheretima* (*Parapheretima*), and because the intestinal caeca reported in 23 were not confirmed. Due to lack of information on intestinal details, Easton (1979: 116-119) was also uncertain about generic placement of '*Pheretima*' *flabellifera* Cognetti, 1911; '*Pheretima*' *touranensis* Michaelsen, 1934; and *Pheretima liangi* Michaelsen, 1922. Nevertheless, Easton (1979:120) added these names to *Pithemera* as new combinations: *Pithemera aimerikiensis* (Ohfuchi, 1941) to the *P. bicincta* species-group; *Pithemera eldoni* (Gates, 1975); *Pithemera mira* (Gates, 1972) to the *P. sedgwicki* species-group; and *Pithemera palaoensis* (Ohfuchi, 1941).

Both *Pi. vitiensis* and *Pi. sempoensis* are described with male pores in transversely oriented elongate slits born upon a pair of glandular areas (perhaps seminal grooves?). Additonally, because Beddard (1892: 131) describes *Pi. vitiensis* with prostatic duct opening "*though a small globular sac on to the exterior*", this does not sound like a copulatory pouche required for inclusion in *Pheretima.*

Pithemera ablata (Ude, 1905)

Pheretima sedgwicki ablata Ude, 1905:451. [Type locality Samoa. Types ?].

Pithemera sedgwicki ablata: Sims & Easton, 1972:232; Lee, 1981: 564, figs. 31-32 (of spermathecae); [Lee (1981) rejected synonymy of Ude's species in *A. godeffroyi* Michaelsen, 1899, cf. Easton (1984)].

Pithemera godeffroyi (part?): Easton, 1984: 119.

(Description from Lee, 1981).

Diagnosis: *Pithemera* with two pairs of spermathecae in 6/7/8. Male pores on 18. Markings, small paired in line with male pores in 17 and 19, sometimes on 16,18 and 20 also; additional paired median papillae on 9-13, 17 and 19-21. Intestinal caeca paired simple, small in 21.

Distribution: *ablata*, Samoa and Tonga (Ude, 1905), Vanuatu (Ude, 1932, Lee, 1981); [cf. *godeffroyi*, Fiji; *sedgwicki sedgwicki*, Fiji, New Guinea, Vanuatu; *sedgwicki cognettii*, New Britain].

Habitat: Ex. rotten logs and *Pandanus* leaves, lowland and *Agathis* forests, and rainforest.

Behaviour: ?

Length: 93-150 mm.

Width: 4-6 mm.

Segments: 89-109.

Colour: Red with yellowish setal rings and intersegmental furrows.

Prostomium: Epilobous (or prolobous).

First dorsal pore: (12/13)?

Setae: Numerous, ca. 36-64.

Nephropores: None.

Clitellum: Annular: ½14-½16.

Male pores: On prominent papillae on 18 in line with the 7th or 8th setae.

Female pore: Median on 14.

Spermathecal pores: Two pairs in 6/7/8 in line with the 6th setae.

Genital markings: Small paired in line with male pores in 17 and 19, sometimes on 16,18 and 20 also; additional paired median papillae on 9-13, 17 and 19-21.

Septa: All present, 5/6-6/7 sometimes thickened; 9/10-12/13 usually thickened.

Dorsal blood vessel: Single.

Hearts: 10-12.

Gizzard: 8 or 8-9.

Calciferous glands : Oesophageal pouches absent.

Intestine origin (caeca, typhlosole): 15 (16); caecum unpaired, median ventral in 21 (in 22 in *sedgwicki*).

Nephridia: Meroic.

Male organs: Testes/funnels metandric, in 11 only in testis sacs; seminal vesicles paired in 11 and 12 (and rudimentary in 13).

Ovaries: In 13.

Prostates: Racemose, multi-lobed in 17-19; large muscular ducts to male pores (no copulatory pouches).

Spermathecae: Paired in 7 and 8; oval sac with thick duct, and small diverticulum ectally with very short stalk.

Gut contents: ?

Remarks: This taxon is elevated to specific status as it is clearly separated from the nominal subspecies, *sedgwicki*, by its one fewer pair of spermathecae. If *Amynthas godeffroyi* (Michaelsen, 1899) is shown to have intestinal caeca in 22, and to otherwise agree, it may again take taxonomic priority over *ablata*. [See also *Pithemera sedgwicki* and *Amynthas godeffroyi*].

Pithemera bicincta (Perrier, 1875)

Fig. 2.22a *Pithemera bicincta*, Mindanao specimen spermatheca, prostate and caeca.
Fig. 2.22b *Pithemera bicincta*, Cook Islands specimen's intestinal caeca and spermatheca.

Perichaeta bicincta Perrier, 1875: 1004. [Type locality Mindoro (?or Luzon), Philippines. Types in Paris Museum (AE 689-692) inspected by Michaelsen (1910: 84)].

Perichaeta bicincta: Michaelsen, 1900: 419 (*species dubius*).

?*Perichaeta violacea* Beddard, 1895a: 407. [Type locality Penang. Syntypes (Sims & Easton, 1972: 181) British Museum 1904:10.5.185-187; 1972:1.12-13; Penang material inspected was "*presumably the types of* violacea" Gates, 1937)]; (*Amyntas violaceus*) Beddard, 1900: 641; Beddard, 1896: 208 (from Trinidad); (*Pheretima violacea*) Michaelsen, 1900: 312; Michaelsen, 1910c: 84; Reynolds & Cook, 1976: 188; Sims & Easton, 1972: 203 [possibly a *Pi. bicincta* synonym, in this account treated as a separate species pending verification of both]. [Non *Perionyx violaceus* Horst, 1893: 72 (sometimes misspelt "violaseus")].

?*Pheretima aimerikiensis* Ohfuchi, 1941: 302, fig. VIII. [From Aimeriki, Palao. Types?].

Pheretima bicincta: Michaelsen, 1935b: 107; Gates, 1937: 346; 1942: 119; 1959b; 1972: 170; 1982: 60 (syn. *violacea*).

Pithemera bicincta: Sims & Easton, 1972: 202 (?syn. *violacea*); Lee, 1981: 563, figs. 29-30 (of spermathecae); Easton, 1981: 60; 1982: 732; Blakemore, 2002, 2008, 2010, 2012, 2016 (syns. *glandis, philippinensis*); DeAssiz et al. (2017: fig. 4).

Pithemera philippinensis James & Hong, 2004: 9, fig.s 2c-d. [Mt Arayat, Luzon]. Nothing they claim differs from *Pi. bicincta* except markings in 17/18-18/19 – but these are already described for *Pi. bicincta* in 18-19 and Gates (1982: 41) says of the highly variable male porophores "*when largest (and then united with genital markings), slightly dislocating 17/18 and 18/19*" so it is well within limits.

Pithemera glandis Hong & James, 2011: 24, figs. 5A-B. [From Luzon too; compared to *Pi. bicincta* that they say "*has paired genital papillae in segments xviii* [17] *and xix* [19]*, and one pair of genital papillae just behind the male pores at 18/19*"].

[Description below taken from above references and pers. obs.].

Diagnosis: *Pithemera* with spermathecae paired in 4/5/6/7/8/9, 0.25 circumference apart. Male pores 0.2 circumference apart minute on porophores of variable shapes on 18. GMs, when present, paired in 18/19 or paired smooth areas extending 18-19 (dislocating 17/18 & 18/19). Clitellum short 14-½16. Intestinal caeca paired, simple, small in 22.

Distribution: Infrequently reported from warmer areas around the world: Philippines, Myanmar, Taiwan, Malaysia (Penang "*presumably the types of* violacea" Gates, 1937), Java, Hawaii, Argentina, Mexico, Venezuela, Cuba, St Thomas, Grenada, Trinidad, Dominica (Brown & Fragoso, 2007), USA (first found in greenhouse in Maine by Gates, 1963; subsequently from Georgia and Florida), Malaysia, Vietnam, India, PNG; West Indies, Japan (Easton, 1981 – see my notes below); Papua New Guinea; Vanuatu (Lee, 1981); Samoa and Fiji (Easton, 1984) and Marshall Islands (Kwajalein Atoll – Ref.

2010), also Brazil (Ref.). Rarely reported from northern Europe, e.g. from Denmark on Skov-og Naturstyrelsen database on introduced taxa www.skovognatur.dk/natur/invasive_arter/images/introarter.xls Jan., 2007]. Cf. *Pithemera violacea* reported from Penang west of Malacca, Grenada in the Antilles and Cook Islands (R.J.B. pers. obs. – on Rarotonga unpigmented *Pi. bicincta* was found in sandy soil and *Pi. violacea* which is deep red/claret in clay loams). In Australia, *Pithemera bicincta* is recorded from Christmas Island south of Java (Gates, 1935b: 94), and from Townsville (Easton, 1982). Recently found in glasshouse at Kew gardens in London and in glasshouse in Hungary (Csuzdi pers. comm. and Ref.) and Dublin Botanic Gardens (confirmed by R.J.B as a **new record for Ireland**). A specimen from Kumejima, Okinawa collected RJB + MN 14th Feb., 2016, deposited in Biwako museum collection (FY2015-11) **confirmed its presence in Japan** (found with *Bimastos parvus* also as a new Ryukyu record), *Pi. bicincta* is since reported as more widespread on mainland of Japan.

Material Examined: Rarotonga, **Cook Islands is a new reco**rd for both *bicincta* and *violacea* by R.J.B; Dublin Botanic Gardens is **new record for Ireland** (Blakemore, 2010 from material in author's collection sent by Dr Olaf Schmidt); Lugait, Mindanao (Feb. 2014) two mature specimens inspected by author, another new record for Philippines. Plus the Kumejima specimen noted above (FY2015-11 - note that DNA tissue samples were taken but not yet analysed).

Habitats: In epiphytes and under leaves of *Pandanus* sp. ferns, under palm trees, in plant pots, swamp forests. On Rarotonga found by R.J.B at Rutaki beach under coconut trees in sandy soil where the gut contents were dark soil and coral grits (*bicincta*), and beside creek at carpark at northside of overland trail in more moist, loamy soil (more like the *violacea* morph or species).

Behaviour: Not much response when handled, docile but exude fluid from dorsal pores.

Length: 33-80 mm.

Width: 2-3 mm.

Segments: 77-101 (125).

Colour: In anterior and dorsum only, weak reddish-brown; (or, *violacea*, deep red).

Prostomium: Open epilobous.

First dorsal pore: Very small sometimes not found, or 11/12 or 12/13.

Setae: Generally numerous, ca. 40-66 per segment, but often fewer in anterior segments, 5-8 having only about a dozen, setae often missing on clitellum.

Nephropores: None found.

Clitellum: Annular, 14-½16.

Male pores: 0.2 circumference apart minute on porophores of variable shapes on 18; irregular in 18 and 19 in one Cook Island specimen; may be in vestigial furrow or sometimes absent (Gates, 1982: 41). Setae vary between the male pores but one often included in each area demarkated as porophore (Gates, 1972: 170).

Female pores: Closely paired on 14.

Spermathecal pores: Five pairs 0.26 circumference apart in 4/5/6/7/8/9 (may vary or be absent as this "species" is parthenogenetic according to Gates (1972, 1982: 41).

Genital markings: Absent, or when present (e.g. *violacea*) paired in 18/19 or (e.g. *bicincta*) paired smooth areas extending from 18-19; (internal genital glands absent, although Gates says they are sometimes present and presumably with external pores).

Septa: 5/6-7/8 thickened; 8/9 absent; 9/10-12/13 strongly thickened.

Dorsal blood vessel: Single.

Hearts: 10,11-12.

Gizzard: Elongate muscular between 7/8 and 9/10.

Calciferous glands: Oesophageal pouches absent.

Intestine origin (caeca, typhlosole): 15; caeca small and simple, paired from 22 (-21); typhlosole from 22.

Nephridia: Meroic.

Male organs: Holandric: Testes/funnels in 10 & 11 in testis sacs, seminal vesicles paired in 11 & 12.

Ovaries: Paired in 13.

Prostates: Racemose, large muscular ducts J- or C-shaped, (no copulatory pouches).

Spermathecae: Paired in 5-9; small duct shorter than ampulla; diverticulum slender, shorter than duct, ovoid chamber (inseminated?).

Gut contents: Dark soil and sand or coral grits.

Remarks: Gates (1972) suspected parthenogenesis as evidence of sperm development was not noted, however present specimens have iridescent testis and funnels (*bicincta*). After inspection of *P. bicincta* types Michaelsen (1910: 84) considered *P. violacea* a probable synonym, and Sims & Easton (1972: 203) based their description of *P. bicincta* on the original description plus "*an examination of the type specimens of* Perichaeta violacea". Indeed, *P. violacea* appears to be a deeper red but otherwise complies morphologically (and preserved specimens may well lack pigment), although it is

possibly ecotypic (pers. obs. in the field, Cook Islands).

Pithemera aimerikiensis (Ohfuchi, 1941) differs slightly in its larger size of 135 mm, in having many more setae anteriorly in 5-8 - numbering 64-86 per segment, and a lack of genital markings. Nevertheless, it appears close to *P. bicincta* and is here retained as a possible syonym.

Pithemera sedgwicki (Benham, 1897)

Fig. 2.23 *Pithemera sedgwicki* after Beddard (1912: fig. 13).

Pithemera sedgwickii Benham, 1897: 201, Pl. 15, figs. 21-f. [From New Britain. Types?].

Pheretima sedgwicki: Michaelsen, 1900: 302.

Pheretima sedgwicki: Beddard, 1912: fig. 13.

Pheretima sedgwicki cognettii Ude, 1932. From New Britain. Types?].

Pithemera sedgwicki: Sims & Easton, 1972: 232; Lee, 1981: 564.

"*P. sedgewicki* (Benbam, 1897)": Gates, 1982: 37.

Distribution: *sedgwicki sedgwicki*, Fiji, New Guinea, Vanuatu; *sedgwicki ablata*, Samoa and Tonga (Ude, 1905), Vanuatu (Ude, 1932, Lee, 1981); *sedgwicki cognettii*, New Britain (Ude, 1932).

Diagnosis *P. sedgwicki* spp-group: *Pithemera* with Intestinal caecum single, mid-ventral in 21 or 22 (or 23?). Spermathecae two or three pairs in (5/)6/7/8.

Remarks: *Pithemera sedgwicki* (Benham, 1897) was described from New Britain. Ude (1905) initially distinguished a subspecies, *P. s. ablata* from Samoa and Tonga, he later (Ude, 1932) recognized another variety from New Britain as *P. s. cognetti* and combined *P. s. ablata* from Vanuatu with *P. godeffroyi* (Michaelsen, 1899) from Fiji. Sims & Easton (1972: 232) transferred all these nominal species to *Pithemera*, but did not resolve synonymies. Easton (1984: 119) also included *P. s. ablata* as a junior synonym of *P. godeffroyi*, however, Lee (1981: 564) had earlier stated that the orginal description of *godeffroyi* had a large pair of caeca from 27 which (if so) would require maintaining *Amynthas godeffroyi* and *Pithemera sedgwicki ablata* independently.

Michaelsen's (1900: 269) description of *P. godeffroyi* has "*Darmblindsäcke einfach, mässig gross*" (Intestinal caece simple, moderately large). ***Pithemera sedgwicki*** has spermathecae in 5/6/7/8 and intestial caecum in 22, while ***P. sedgwicki ablata*** has

spermathecae in 6/7/8 and caecum in 21; it is elevated to species level and redescribed above. (See *Pithemera ablata*, also ?*Amynthas godeffroyi*).

Genus ***Planapheretima*** Michaelsen, 1934

Type-species: *Pheretima moultoni* Michaelsen, 1913.

Diagnosis: Megascolecidae with an oesophageal gizzrd in 8, intestinal caeca sometimes present, intestinal gizzards absent. Perichaetine with ventrally crowded setae, body depressed (flattended) often forming "*creeping sole*". Male pores simple on 18, prostates racemose. Often brightly or cryptically pigmented, possibly as defence due to exposed arboricolous habitats.

Distribution: Areas of high humidity in Szechwan (China), Myanmar, Sumatra, Borneo, Celebes, New Guinea, Vanuatu. About 15 species, none known outside this region of endemicity. Other possible members are *Amynthas? acidophilus* (Chen, 1946: 111) and *Amynthas? jaoi* (Chen, 1946: 112) that were said to be leafcrawlers from Szechuan, the enigmatic *Amynthas martiorum* (Michaelsen, 1938) from Papua New Guinea, Vietnamese *Planapheretima*? *plumatomusculata* (Thai, 1982: 829) and *Pl. rarusa* (Thai, 1997: 1) both described as a 'leaf-crawlers', and Burmese *Amynthas*? *sonellus* (Gates, 1936: 458). *Amynthas hinudinarius* (Gates, 1958: 14) and *Metapheretima speiseri* (Michaelsen, 1913) were removed from the genus by Easton (1979: 92, 119), whereas the anomalous Burmese *Planapheretima arboricola* (Rosa, 1890: 119) (syn. *Pheretima arboricola* Gates, 1936: 399) that caused Gates (1972: 170) to question whether the (sub)genus was monophyletic, possibly merits its own genus.

Perhaps the most widespread single taxon is *Planapheretima hasselti* (Horst, 1883) listed by Easton (1979: 73 with synonym *P. frondicola* Michaelsen, 1934) from Lebang, Sumatra and Mt Dulit Sarawak (for *frondicola*). Diagnosis is spermathecal pores in 5/6/7 and no markings other than large oval male porophores on 17-18.

The material mis-identified by Michaelsen (1922) as *hasselti* was re-assigned to the *Amynthas morrisi* spp-group by Easton (1979: 73) as it lacks the depressed body.

Genus ***Polypheretima*** Michaelsen 1934

Pheretima (*Polypheretima*) Michaelsen, 1934: 15; Sims & Easton, 1972; Easton, 1979.

Type-species: "*Pheretima* (*Polypheretima*) *stelleri* Mich. var. *everetti* (Bedd.)" (= *Perichaeta stelleri* Michaelsen, 1891 and *P. everetti* Beddard & Fedarb, 1895). [Type locality of *stelleri* Sangihe (Sangir) Island, northern Celebes (Sulawesi), Indonesia. Types of *stelleri* ("*Paratypes*" according to Sims & Easton, 1972: 254) British Museum 1904:10.5.162 and Hamburg Museum V.338 from "*Sangir*"; or these "*syntypes*" plus Leiden 1903 from "*Sangihe" and another specimen Amsterdam 303 from adjacent "Kepulaud Taulaud*" (of Sangir-Talaud Island group); plus Bone Valley, Celebes - the type locality of *stelleri annectens* syntype with a further report by Michaelsen (1899) from the Matinang range, Celebes]. Note: Sims & Easton (1972: 252), Easton (1976: 44), and Easton (1979: 55) include *Perichaeta stelleri* Michaelsen, 1891 (syn. *Amyntas stelleri annectens* Michaelsen, 1899: 42) in a *Polypheretima elongata* (Perrier, 1872) 'species-complex', as noted below, whereas Gates (1972: 183) long suspected that *P. stelleri* a was actually a synonym of *Po. elongata*. Cf. *Po. everetti* from Balabac Isl., Palawan, see description below.

Diagnosis: Megascolecidae with an oesophageal gizzard in 8; lacking intestinal caeca and intestinal gizzards. Setae perichaetine, sometimes numerous, but not crowded ventrally. Body not flattened. Male pores on circular porophores, lacking associated crescent markings, occasionally within copulatory pouches, lacking penial bodies (cf. *Metapheretima*). Often polythecal. Nephridia absent from spermathecal ducts.

Distribution: Endemic region includes Vietnam, Malaysia, Indonesia and New Guinea. Japan is now removed from this range cf. Easton (1979: 43) since the supposedly Japanese endemic, *Polypheretima iizukai* (Goto & Hatai, 1899), is a misidentification of *Amynthas grossus* (Goto & Hatai, 1898), itself a junior synonym of *Amynthas fuscatus* (Goto & Hatai, 1898) – see Blakemore (2003).

Easton (1979) included 37 species; and ca. seven species have wider distributions thought due to transportation: *Polypheretima brevis* (Rosa, 1898: 283) recorded from Christmas Islands near Java and from Tonga was believed by Easton (1979: 41) to originate from New Guinea; *Polypheretima pentacystis* (Rosa, 1891: 400) is known only from Seychelles and Madagascar and Easton (1979: 49) was unable to explain this distribution without invoking the mechanism of human transportation. *Polypheretima annulata* (Horst, 1883) is known from Sunda Island, the Malay Peninsula and West Papua, *Po. fida* (Michaelsen, 1913) is possibly introduced to the Loyalty

Islands, New Caledonia (where other cosmopolitans *A. rodericensis, A. taitensis, Ph. montana*, and *Po. elongata* are also found), and *Po. voeltzkowi* is outside the 'pheretima domain' in Comoro Islands (and Vanuatu). Easton (1976) thought the wide distribution of *Po. everetti* on and around Borneo was natural, nevertheless some of the peripheral records possibly are due to transportation. *Po. iizukai* from Japan was put in synonymy of *A. fuscatus* by Blakemore (2003).

The two main cosmopolitans, *Po. elongata* and *Po. taprobanae*, described below.

Key to Peregrine *Polypheretima* SP – Spermathecal Pores.

1. Spermathecal pores a segmental pair postsetal in 5 ..... *Po. voeltzkowi* (part)
   SP segmentally paired presetal in 7 and 8 ..... *Po. annulata* spp-complex
   Spermathecal pores intersegmental (or absent) 2
2. Male pores simple, superficial ……. 3
   Male pores in deep or shallow copulatory pouches ….....…. 4
3. Spermathecal pores in 4/5/6 and occasionally 6/7 ……..... *Po. fida*
   Spermathecal pores in 5/6/7/8 ……..... *Po. brevis* [Note: New Guinean '*Pheretima*' *flabellifera* Cognetti, 1911 keys here, but its GMs differ].
   Spermathcal pores in 7/8 …… *Po. taprobanae*
   Spermathecal pores absent (GMs 17 and 18) ..... *Po. voeltzkowi* (part)
4. Spermathecal pores wide in 4/5/6/7/8/9 ……..…… *Po. pentacystis*
   Spermathcal pores absent or paired or batteries in 5/6 and/or 6/7 ….. 5
5. Spermathecae absent, or <5 on each side in furrows 5/6 and/or 6/7 …. **Po. elongata*
   Spermathecae more extensive or batteries more numerous …… 6
6. Spermathcae paired or in batteries in 6/7/8 (at least) …. **Po. lesonea* from Sarawak.
   Spermathecal batteries in 5/6 only …… **Po. phacellotheca* from Mt Masarang, above Tomohon, northeast Celebes (Sulawesi) and from Buru Island to the east.
   Spermathecal batteries in 5/6/7 …….. 7
7. Spermathecae ca. 10-28 on each side; ca. 40-130 setae on segment 7 … **Po. stelleri* (syn. *stelleri annectens*) from islands of northern Celebes (Sulawesi).
   Usually <15 spermathecae on each side; ca. 30-130 setae on 7; genital markings paired (or absent) ……..… **Po. everetti* widespread in Borneo and adjacent region.
   Usually <12 spermathecae on each side; <40 setae on segment 7; genital markings mid-ventral ……..… **Po. kinabaluensis* from Mt Kinabalu, Borneo.

* Five or six species comprising a '***Polypheretima elongata* species-complex**' are differentiated in the table below after Gates (1972) and Easton's (1976; 1979) biometric computations; these parthenogenetic taxa and their synonyms intergrade and, if combined, would each assume the earlier name. For full synonymies see Easton (1976: 38-44; 1979) although Easton (1976: 44) noted that relationships between *stelleri* and *everetti* and *stelleri* and *phacellotheca* are unknown, and Gates (1972) thought *stelleri* a synonym of *elongata*.

Table of marker attributes for *Po. elongata* spp-complex modified from Easton (1976) wherein some characteristics were mistaken cf. original descriptions.

Species group	Author/date/ (:page)	Setae:segment (on se.g. 7)	*Sperma-thecal pores	*Spermathecae count/battery
Po. elongata	(Perrier, 1872)	High (60-130)	None or 5/6 and/or 6/7	Small (0-5)
Po. stelleri	(Mich., 1891)	High (35-130)	5/6/7	Large (10-28)
Po. everetti	(Beddard & Fedarb, 1895: 69)	High (30-130)	5/6/7	Medium (3-15)
Po. kinabaluensis	(Beddard & Fedarb, 1895: 71)	Low (<40)	5/6/7	Medium (6-12)
Po. phacellotheca	(Michaelsen, 1899)	High (80)	5/6	Medium (9-12)
Po. lesonea	Easton, 1979	?	(5/)6/7/8(/9)	Small (1+)

***Po. elongata* spp-complex** GMs usually paired from 19-30, cf. unpaired, midventral 19-20,21 in *Po. kinabaluensis*.

*Two of Easton's *Po. everetti* synonyms, at least, must be questioned as *P. barami* lacked spermathecae (as in *Po. elongata*), and *P. stelleri bonensis* had spermathecal groups of 18-26 (as in *Po. stelleri* sensu stricto); moreover *P. stelleri klabatensis* lacked GMs (as in *Po. annamensis*) but perhaps still belongs to the *everetti* group (see below).

Polypheretima annulata (Horst, 1883)

Fig. 2.24 *Polypheretima annulata* (after Easton, 1979, fig. 17a with no known © mark).

Megascolex annulatus Horst, 1883: 195. [Type locality 'Malayan Archipelago' but cited by Easton (1979: 36) as 'Indonesia' - see Distribution below. Syntypes in Leiden, 1855].

Perichaeta annulata : Horst, 1890: 236, fig. 7; 1893: 29; Beddard, 1895a: 426.

Amynthas annulatus : Beddard, 1900: 634.

Pheretima annulata : Michaelsen, 1900: 253.

Metapheretima annulata : Sims & Easton, 1972: 233.

Pheretima fakfakensis tetratheca Michaelsen, 1910: 254. [From Gt. Kai, Kepulauan Kai and (Gates) from Bogor, Java. Syntypes Hamburg v3032]; Gates, 1936: 385.

Pheretima kochii Cognetti, 1913: 293. [From Etna Bay, West Papua. Type Amsterdam 275. Name sometimes spelt *kochi*].

Pheretima invisa Cognetti, 1913: 294. [Sabang, West Papua. Syntype Amsterdam 270].

Pheretima schaedleri Michaelsen, 1922: 52. [From Skrow, West Papua. Types Leiden 1822].

Metapheretima annulata species-group Sims & Easton, 1972: 233 [group comprised *annulata, invista, kochii, schaedleri*; with segmental spermathecal pores, but *fakfakensis tetratheca* with pores in 6/7/8 was kept separate, cf. Easton (1979)].

Polypheretima annulata : Easton, 1979: 34-35, fig. 17a [(syn. *fakfakensis tetratheca, kochii, invisa, schaedleri*); part of an '*Polypheretima annulata* species-complex'].

Taxonomic Notes: Taxonomic details are found in Horst (1883) and Easton (1979). Reynolds & Cook (1976: 71) cite *Megascolex annulatus* Horst, 1883 but mistakenly include a later mention of the same taxon as *Perichaeta annulata* by Horst (1890) as a different species, and Reynolds & Cook (1981: 30) give it the same type specimen: RNHL 1855.

Michaelsen (1899c: 223) believed Beddard's poorly described *P. sandvicensis* from Hawaii to be a synonym of this taxon, but this appears not to have been supported by Michaelsen (1900) and it is most likely *M. californica*.

The other member of the *Polypheretima annulata* species-complex of Easton, 1979 is ***Po. fakfakensis*** (Cognetti, 1908) from Western New Guinea that has spermathecal pores in 7, 8 and 9.

Diagnosis: Length 58-195 mm. Dorsal pores from 10/11-13/14. Spermathecal pores segmental, paired and presetal in 7 and 8. Genital markings small, paired postetal on 7, 8, 9 and more pairs on 17-19 less wide than male pores. Colour blackish with white rings equatorially on each segment.

Distribution: "*Malayan Archipelago*" (Horst) which in the 1880s included Java and other islands; Indonesian Kepulauan Islands, southwest West Papua, Java and (Michaelsen) Sunda Islands, Indonesia. It thus appears that the species is more widepread than Easton (1979, fig. 16) supposed, and this may be due to transportation.

Polypheretima brevis (Rosa, 1898)

Fig. 2.25 *Polypheretima brevis* (modified after Easton, 1984, fig. 1 with no © mark).

Perichaeta brevis Rosa, 1898: 288. [From Christmas Island, Indian Ocean. Syntypes (3 of, immatures) BM: 1898:10.28.1-2].

Amynthas brevis: Beddard, 1900: 636.

Pheretima brevis: Michaelsen, 1900: 257; Gates, 1935: 94.

Metapheretima brevis: Sims & Easton, 1972: 180, 233.

Polypheretima brevis: Easton, 1979: 41; 1984: 116, fig. 1e.

Diagnosis: *Polypheretima* with simple male pores c. 0.28 C apart. Length 15-24 mm by 1.5-2.5 mm. Segments 66-80. First dorsal pore 12/13/14. Setae 46-52. Spermathecae about 0.5 C apart in 5/6/7/8. GM absent (from syntypes), or present as large, paired presetal marks on 8 and 18 just median to lines of spermathecal pores and male pores, respectively; a more median pair on 17. Septa 5/6-13/14 membranous. GM glands present. Hearts 10-12. Holandric. Psudovesicles in 13 or 14. Diverticula almost as long as spermathecal ampullae, simple.

Distribution: Christmas Island, Australian Territory in the Indian Ocean (Gates, 1935); and under 'salata' tree and secondary *Rhus* forest near plantations Tongatapu Isls., Tonga (Easton, 1984 and Ref.).

Notes: Sims & Easton (1972: 191) inspected type and say intestinal caeca are absent. Easton (1979; 1984) believed it similar to *Po. bifaria* from Papua New Guinea and that it has probably been introduced to the islands by agency of man. Its origin is unknown.

Polypheretima elongata (Perrier, 1872)

Fig. 2.26 *Polypheretima elongata* athecal Biloela specimen (a) ventral view, (b) prostate, (c) prostomium, (d) cocoon and (e) posterior. Spermathecae and caeca absent.

Perichaeta elongata Perrier, 1872: 124, fig. 70 (of prostate). [Type locality Peru. Type in Paris Museum: AE633, in fragments]; Beddard, 1895a: 431 (who claims only one pair of spermathecae in segment 6 (i.e., opening in 5/6), cf. Michaelsen, 1900: 265 who allows a pair of spermathecae in 4/5, although this is probably a mistake for 5/6?; and cf. Gates, 1972: 182 who allows groups of spermathecae

up to 2-5 in 5/6/7).

Perichaeta biserialis Perrier, 1875: 1044. [From Philippines. Types in Paris Museum: 635-644 - Paris Museum specimen numbers are from Reynolds & Cook (1976); however Easton (1976: 51) footnotes that at least one specimen collected after 1875 could not be a type]; Beddard, 1890: 63, figs. 4, 7 (specimens from Manila, Philippines); 1895a: 430; Michaelsen, 1900: 256 (syn. *acystis*, *monocystis*).

Amyntas biserialis : Beddard, 1900a: 638 (syn. *acystis*).

[?*Perichaeta luzonica* Perrier, 1875: 1044. Designated type-species of the overlooked sub-genus *Megascolex* (*Perriera*) Vaillant, 1899 by Sims & Easton (1972: 205) thereby preventing this subgenus from competing for priority with other genera. Note there is some conflict here as Jamieson (1975: 140) lists Paris type AE634 (A724) of *Perichaeta luzonica* Perrier, 1875 from de Bataan, Ile Lucon and apparently collected by M. Laglaize in "1876" in synonymy of *Polypheretima elongata*, but Jamieson (1975: 141) on the next page also lists AE634 as from different locality of Lucon, Mindoro! Synonymy and location are likely mistakes].

Megascolex elongata: Vaillant, 1889: 81.

Perichaeta acystis Beddard, 1895a: 423 [(= *biserialis*: Beddard, 1890: 63 nom. nov., non Perrier, 1875). [From Luzon, Philippines].

Perichaeta monocystis Horst, 1899: 202 (lapsus pro *acystis* Beddard, 1895).

Amynthas elongata: Beddard,1900: 650.

Pheretima elongata: Michaelsen, 1900: 265; Gates, 1937: 352 (syn. *biserialis*); 1958: 8 (?syn. *stelleri*); 1959b; 1972: 182 [syn. *aelongata* Gates, 1926: 444 (misspelling or illegal emendation); non *elongata* : Ohfuchi, 1956: 148 (= *A. morrisi*)]; 1982: 45 (syn. *biserialis, ?stelleri*).

Metapheretima elongata: Sims & Easton, 1972: 205 (syn. *biserialis*) in a species-complex; Easton, 1976: 53 (syn. *biserialis*, *acystis*).

Polypheretima elongata: Easton, 1979: 53; Easton, 1981: 61 [syn. *biserialis*; non *elongata* : Ohfuchi, 1956 (= *Amynthas morrisi*)]; Easton, 1984: 733.

Note: For full citation synonymy see Gates (1972), Easton (1976; 1979).

Diagnosis: *Polypheretima* with male pores in shallow pouches (no stalked glands). Spermathecae absent or in low numbers (1-5 each) in batteries in 5/6 and/or 6/7. Setae numerous (80-130 per segment). Genital markings paired in line with male pores from 19 and successive segments. Intestinal caeca absent.

Distribution: *Polypheretima elongata* forms a species-complex with four or five other morphologically similar species from southern Philippines, western Indonesia and Borneo [*Po. stelleri* (Michaelsen, 1891), *Po. everetti* (Beddard & Fedarb, 1895: 69), *Po. kinabaluensis* (Beddard & Fedarb, 1895: 71), *Po. phacellotheca* (Michaelsen, 1899) and possibly *Po. lesonea* Easton, 1979]. Its home may well be Borneo/Celebes/Philippines (Gates, 1972) or, as cogently put forward by Easton (1976), from eastern Indonesia/Bali/Gt. Bastard Island/Flores. It is the only widely allochthonous member of the complex, often being reported from tropical regions throughout the world and, less frequently, from the warmer parts of the temperate regions: South and Central America, the Caribbean West Indies (e.g. Gates, 1937 lists it from Cuba and Puerto Rica; Gates, 1958 from British Guiana; Brown & Fragoso, 2007 list it from Peru, Brazil, Colombia, Belise, Guayana, Costa Rica, Panama, Venezuela, Guyana, Surinam, Mexico, Jamaica, Haiti, Puerto Rico, Martinica, Bonaire, Cuba, Dominica, Antigua), St Helena (Gates, 1937: 318, MCZ:IZ:95261), Madagascar, Sri Lanka, India, Pakistan, Bangladesh, Myanmar, Vietnam, Laos, Cambodia (Thai & Do, 1989), Philippines, Taiwan, Kei, Papua New Guinea, New Britain, New Caledonia, Caroline Islands, Hawaii, Rarotonga, Tahiti, Africa, Australia and Oman (see Gates, 1972 and Easton, 1976 for further details). Samoa (Vargo, 1999). A report from USA in checklist by Gates, 1982 is questionable as it was based upon a PhD study in Louisiana noted by Gates (1958). Ogasawara Islands (Ohfuchi, 1940), Gates (1972: 183) remarked that the Ryuku specimens identified by Ohfuchi (1956: 148) as *P. elongata* were mistakes (for *A. morrisi*) but that other specimens referred to *P. biserialis* by Ohfuchi (1956: 151) were *P. elongata* so it does occur in Japan (Ryukyus/Okinawa). In Australia, it shows a restricted distribution, expanded slightly by the present study, in the Gladstone area of Queensland (Easton, 1984 and pers. obs.).

Locality: Biloela, Yeppoon, Rockhampton, Qld; Rarotonga, Cook Islands (**new records**) and from Rice paddy and other soils on organic farms in Philippines (Blakemore 2016).

Habitat: Mainly in clay soils: under cultivation (especially zero-till plots Biloela); in creekbank (Yeppoon); suburban garden/lawn (Rockhampton, Biloela and Rarotonga), also in vegetable gardens and under Taro (Rarotonga, Cook Islands).

Exceptional in having preference for clay soil rather than sandy soil in choice chamber expeiments (Blakemore, 1994).

Registration No.: Numerous specimens, some now in ANIC.

Behaviour: Rather sluggish when captured, but escapes rapidly along its burrow

systems in the soil so that complete mature specimens are difficult to obtain. This large species exudes copious uncoloured coelomic fluid when stressed.

Length: Often contract markedly on preservation, 75-300, one mature specimen in the current study reached >450 mm in life (mass 8 g).

Width: Ca. 3-6 mm, mean 5.5 mm.

Segments: Mean 200 (range 136-297).

Colour: Pigmentless grey with pink anterior in life, soil and blood vessels, especially the dorsal vessel, show through epidermis; clitellum buff.

Prostomium: Prolobous or closed epilobous ("*rudimentary*") with slight or marked V-shaped notch ventrally on peristomium.

First dorsal pore: 12/13 or 13/14, then only clearly visible after clitellum.

Setae: Numerous, 66-80 (or up to 130 in larger specimens), setae a-d,e somewhat darker and enlarged but decreasing in size laterally; slight midventral gap; setae generally obscured on clitellum.

Nephropores: None.

Clitellum: Annular 14-16.

Male pores: Within eversible, lateral crescentic grooves on raised porophores on 18 with up to ten setae between.

Female pores: Single, central within small circular depression on 14.

Spermathecal pores: Absent from all specimens inspected here; (morphs reported with thecal batteries each with rarely more than 3 spermathecae in 5/6 and/or 6/7).

Genital markings: Paired largish, raised, smooth disks, with presetal centres on five (or six) segments in 19-23,24.

Septa: 4/5-7/8 very strongly thickened; 8/9-9/10 aborted; 10/11 weaker to base of gizzard.

Dorsal blood vessel: Single, continuous onto pharynx (ventral vessel bifurcates into hairpin loops on each side under gizzard).

Hearts: Large in 7, absent from 8 and 9, then in 10-12, 13.

Gizzard: Large, muscular and spherical in space between 8/9 and 9/10.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): Intestine in 14 widens appreciably in 15,16.

Nephridia: Meroic, forests of micro-meronephridia in each segment.

Male organs: Testes/funnels not seen (in sacs); large seminal vesicle fill 11 and 12.

Ovaries: Pair of large tongue-like glands in 13 (ovisacs or pseudovesicles present in 14).

Prostates: Racemose with looped muscular duct.

Spermathecae: None; or polythecal batteries in 5/6 or 6/7 or 5/6/7.

Gut contents: Fine clay soil material.

Notes: Although remarkably long specimens are frequently found (as the name *elongata* suggests), shorter mature forms (ca 100mm) are also reported (misidentifications?). The male pores may be everted on preservation.

Remarks: Biloela and Rockhampton are new records for the distribution of this peregrine, parthenogenetic species in Australia. Its original home is in the Indonesian region, and since this is closer to Western Australia and the Northern Territory, it is reasonable to presume that it will eventually be recorded there.

A marked preference for clay soils was found for *Po. elongata* in behavioural trials undertaken as part of this study, and field collections have supported this finding. In glasshouse trials this species was responsible for a 30% reduction in grass yields in a cracking clay soil (but 30% increase in a sandy soil) although its survival was better in the clay. Second trials, using an alluvial dark clay, demonstrated a doubling of grain sorghum yield with this species compared to control cores of soil and, over 4 months period, each mature worm produced an average of 8 viable offspring.

This worm was observed to have a very dramatic effects on the structure of soil by producing copious surface casts as ribbons and globules and creating (1 cm) wide vertical burrows which greatly facilitate water infiltration.

Differentiation of cocoons from soil was difficult as they are of a similar dark yellow to almost black colour. Hatchlings have been found with defects possibly from parthenogenesis (a pair co-joined at mouth; another astomate that soon died). Easton (1979: 53) stated that spermathecal batteries are usually present in about 50% of clitellate specimens in the indigenous range, which reduces to about 15% in introduced populations. Spermathecae were not found in any the current specimens.

Reported use of this species in vermicomposting in India have not been confirmed, and it is possible that this is a misidentification.

Gates (1972: 183) notes that *P. elongata* (15.6% of earthworm population) along with *Pontoscolex corethrurus* was implicated in rendering a South Indian soil cloddy and unproductive by (Pattarudriah & Sastry, 1961 *Mysore Agric. Jour.* **36:** 4). Seepage from taro patches on Kauai, Hawaii; from rice paddies on Taiwan (Gates, 1959b, 1982); and from the famous 2,000-year-old Banaue mountain rice terraces of Ifugao, Philippines were all attributed to morphs identified by Gates as *Po. elongata* – similarly identified by

Joshi *et al.* (2000) and Hairiah *et al.* (2001), although Joshi had earlier stated:

"*The "giant earthworms" or "Mystery worm" (Pheretima spp./ Metaphire spp.) destroy the rice terrace walls by burrowing holes, and causing water stress and encouraging weed growth thereby affecting rice production in Banaue rice terraces (Personal communication: Dr. Samuel James, USA)*" [http://www.agnet.org/activities/sw/2006/589543823/paper-729213301.pdf].

Gates (1982) reports that the Banaue worms were known locally to first occur beside a Belgian preist's outhouse in the 1930s.

DNA from Blakemore(2016) e.g. GenBank: KT626583.1, KT626584.1, KT626591.1:

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>Pe4 Po. elongata 29/I/2014 Hascienda Remedios farm
CCTATACTTTATTTTAGGAATTTGAGCTGGAATAATTGGAGCTGGAATAAGACTACTAATTC
GAATTGAATTAAGACAACCAGGTTCATTTCTCGGCAGAGATCAATTATATAATACTATTGTT
ACTGCGCACGCATTCTTAATAATTTTCTTCTTAGTTATACCAGTATTTATTGGTGGATTCGG
AAACTGACTTCTACCGCTAATATTAGGAACACCAGATATAGCATTTCCACGACTAAATAATA
TAAGATTTTGACTGCTGCCACCATCATTAATTCTACTTGTATCTTCTGCTGCTGTAGAAAAG
GGAGCAGGAACAGGATGAACCGTATACCCGCCACTAGCAAGAAACATTGCACATGCTGGACC
TTCAGTAGACCTAGCAATTTTCTCTCTACACTTAGCAGGTGCCTCATCAATTCTTGGGGCAA
TCAACTTTATTACTACTGTCATTAATATGCGATGATCAGGCCTACGACTAGAACGAATTCCC
CTATTTGTATGAGCAGTGGTAATCACAGTGGTACTACTACTACTATCGCTACCAGTTCTTGC
TGGAGCCATTACAATACTACTTACAGATCGAAATCTTAATACATCATTCTTTGATCCAGCAG
GTGGAGGAGACCCAATCCTATACCAGCATTTATTC
```

Blast has several 99-100% matches for Philippines, Vietnam & India, one for Mexico, viz. GenBank: LC475692.1 as "Acanthodrilidae sp." (sic) by Ideda & Mac Callaham.

Polypheretima everetti (Beddard & Fedarb, 1895)

Fig. 2.27a *Polypheretima everetti* (original from YNU north Borneo specimens, 2006).
Fig. 2.27b *Polypheretima everetti* (after Easton, 1976: fig. 5)
See also Beddard (1896: fig. 196).

Perichaeta everetti Beddard & Fedarb, 1895: 69. [Type locality stated by Beddard & Fedarb as "*Mount Kina Balu*", but based on type labels Easton (1976: 43) redesignated it under what is now ICZN (1999: 76A) as on the adjacent Balabac Island, Palawan southern Philippines. Syntypes in British Museum BM1904: 10:5:38-40 inspected by Easton (1976: 51)]; Beddard, 1895a: 428 (non *Amynthas stelleri everetti* : Michaelsen, 1899: 43: 1900: 306 where *P. everetti* was

combined with *P. kinabaluensis*). [GMs paired on 19-21; spermathecae 12-17 of in segments 6 and 7].

Perichaeta papillata Beddard & Fedarb, 1895: 70, 71. [Merabah, Borneo. Syntypes BM:1904:10.5.1265-70 inspected by Easton, 1976: 52]; Beddard, 1895a: 428 (redescription). [GMs paired on 19-29; spermathecae 7 per segment].

Perichaeta sarawacensis Beddard and Fedarb, 1895: 71. [Labuan, Sarawak. Holotype BM:1904.10.5.150 inspected by Sims & Easton, 1972: 254]; Beddard, 1895a: 429. [GMs paired on 19-22; 14 spermathecae 14 in segments 6 and 7].

?*Perichaeta barami* Michaelsen, 1896: 203 [Baram River, Sarawak and/or (Minahassa) North Celebes, Michaelsen was unsure. Holotype Hamburg v.3835 inspected by Sims & Easton, 1972: 254 and they only give the former locality; same specimen listed by Easton, 1976: 51 as from "Minahassa" and Easton, 1976: 52 as "Baram River"]. [Grey, setae 42-55 per segment, GMs on 19,20, spermathecae absent (as in *Po. elongata*)].

Amyntas stelleri seriatus Michaelsen, 1899: 44 (originally spelt *seriata*). [From either Uangkahulu Valley or Buol, North Celebes. Paratype Hamburg v.5197 inspected by Sims & Easton, 1972: 254; and v.5198 inspected by Easton, 1976: 51. [Brownish with violet shimmer, setae 42-111, GMs 19-22,23, spermathecal groups of 3-6].

?*Amyntas stelleri klabatensis* Michaelsen, 1899: 46. [Klabat, North Celebes, 1,800m. Paratype Hamburg v.5196 inspected by Sims & Easton, 1972: 254; claimed as "Holotype" by Easton, 1976: 51. Setae 72-120, no GMs, spermathecal groups of 8-11 (lack of GMs is a departure from *Po. everetti* diagnosis below and is therefore similar to *Po. annamensis* (Stephenson, 1931) that however is bithecal].

?*Amyntas stelleri bonensis* Michaelsen, 1899: 45. [From Bone Valley, North Celebes. Types lost]. [Blue in life, setae ca. 130, GM paired in 19, spermathecal groups of 18-26 (as in *Po. stelleri* s. stricto)].

Amynthas stelleri everetti (part) : Michaelsen, 1899: 43 (where *P. everetti* was combined with *P. kinabaluensis*).

Pheretima stelleri everetti (part) : Michaelsen, 1900: 306.

Pheretima stelleri koroensis Michaelsen, 1910: 109 [Koro Valley, Celebes (Sulawesi). Holotype listed on Basel Museum type website: http://www.nmb.bs.ch/NaturmuseumBasel/LinksNMB/Sammlung/Kataloge/Guertelwuermer.xls].

Pheretima stelleri mahakkami Michaelsen, 1922: 25 [Mahakkam River, Sarawak. Holotype Leiden 1897 inspected by Sims & Easton, 1972: 254].

Pheretima (Pheretima) beranensis Michaelsen, 1928: 23. [Birang River, Beran district, Kalimanton. Type(s) Hamburg v.10576 inspected by Easton, 1976: 52].

Pheretima (Pheretima) baritoensis Michaelsen, 1932: 9 [Boentok on the Barito River, Kalimanton. Types lost].

Pheretima (Polypheretima) beranensis tinjarana Michaelsen, 1934: 25 [Tinjar River, Long Lejok, Sarawak, http://jcs.biologists.org/cgi/reprint/s2-77/305/1.pdf. Syntypes BM:1933.10.6.12-20 and Hamburg v.11951 inspected by Sims & Easton, 1972: 254 and Easton, 1976: 52].

Metapheretima everetti: Sims & Easton, 1972: 233; Easton, 1976: 41 [syns. *papillata, sarawacensis, barami, stelleri seriatus* (originally spelt *seriata*), *stelleri klabatensis, stelleri bonensis, stelleri koroensis, stelleri mahakkami, beranensis, baritoensis, beranensis tinjarana*].

Polypheretima everetti: Easton, 1979.

Taxonomic Notes: Attributed to Beddard & Fedarb (1895: 69), although Beddard (1895: 429) later described it as a "*new species*". Two of Easton's synonyms, at least, must be questioned as *P. barami* lacked spermathecae (as in *Po. elongata*) and *P. stelleri bonensis* had high spermathecal groups of 18-26 (as in *Po. stelleri*); moreover, *A. stelleri klabatensis* lacked genital markings as described in the diagnosis below. This taxon is originally designated as the type of the genus: see Michaelsen (1934: 25), cf. Sims & Easton (1972), Easton (1976, 1979: 28) who have *P. stelleri* Michaelsen, 1892 as type which, to me, seems to be a mistake.

Diagnosis: *Polypheretima* with male pores in copulatory pouches without stalked glands. Colour reddish-purple. Length up to 300 mm with up to 260 segments. Spermathecal batteries (each with 3-12 spermathecae) in 5/6/7. Setae numerous (up to 130 per segment in large specimens). Genital markings paired, presetal in line with male pores in some or all of 19-21,22,23. Holandric. Intestinal caeca absent. Cf. *Po. elongata* and *Po. stelleri*.

Distribution: Balabac Island south of Palawan, Phililppines (new type locality rather than Mt Kinabalu by Easton, 1976: 43); north and west Celebes; Borneo including Mt Kinabalu (from 1,200-2,400m); and Lombok, Indonesia (350-450m only). Easton (1976: 43) claims that this species is unknown outside its indigenous range, although this is quite extensive and some of the island records (e.g. Balabac and Lombok) may be due to transportation. It occurs on lowlands on Borneo yet is sympatric with *Po.*

kinabaluensis at higher altitude on Mt. Kinabalu (Blakemore *et al.* 2007).

Notes: Although it is similar to *Po. elongata*, and sympatric with this and other members of the *Po. elongata* species-complex - e.g. Easton (1976: fig. 6) shows it to occur thoughout Borneo and with *Po. elongata* on Lombok; *Po. phacellotheca* and *Po. stelleri* in northern Celebes; and *Po. kinabaluensis* on Mt Kinabalu – but Easton (1976: 42) says that there is no indication of hybridization among the species. Easton (1976: 52) separated off one Lombok specimen (Berlin 7214) from the type series of *Po. badia* (Ude, 1932) as *Po. everetti*.

Polypheretima pentacystis (Rosa, 1891)

Polypheretima pentacystis (after Easton, 1979: fig. 21a with no known © mark).

Perichaeta pentacystis Rosa, 1891: 400, fig. 10 (of two spermathecae). [Type locality Mahe Isl., Seychelles. Holotype in Vienna, 3996 inspected by Easton (1979)]; Beddard, 1895a: 422.

Amynthas pentacystis: Michaelsen, 1899: 95. [From Nossibe, Madagascar, specimens in Hamburg, v.5113]; Beddard, 1900: 614.

Pheretima pentacystis: Michaelsen, 1900: 294.

Metapheretima pentacystis: Sims & Easton, 1972: 233.

Polypheretima pentacystis: Easton, 1979: 48, fig. 15a, 21a.

Diagnosis: *Polypheretima* with male pores in copulatory pouches (no stalked glands). Spermathecal pores paired in 4/5/6/7/8/9 converging from 0.82-0.62C apart (i.e., situated dorsally). Genital markings large, paired in 8, 17 and 19. Holandric. Caeca absent.

Distribution: Seychelles (Mahe), Madagascar (Nossi-Be), most likely by introduction.

Polypheretima taprobanae (Beddard, 1892)

Fig. 2.28 *Polypheretima taprobanae* Samford specimen (a) ventral view, (b) prostate, (c) spermatheca (d) prostomium and (e) posterior.

Perichaeta taprobanae Beddard, 1892a: 163. [Type locality Sri Lanka. Types from Oxford now BMNH 1904:10:5:163-4, 1972:1:6-11].

Perichaeta pauli Michaelsen, 1897: 234. [From Sri Lanka].

Pheretima taprobanae typica: Michaelsen, 1900: 308.

Amynthas taprobanae: Beddard, 1900: 648 (syn. *pauli*).

Pheretima taprobanae: Stephenson, 1923: 312; Gates, 1937: 371; 1972: 220 [Gates, (1937) inspected probable BM types].

Metapheretima taprobanae: Sims & Easton, 1972: 233.

Polypheretima taprobanae: Easton, 1979: 45 (syn. *pauli*); Easton, 1982: 734.

Polypheretima taprobaena (laps.): Easton, 1979: 45.

Diagnosis: *Polypheretima* with simple male pores (no stalked glands). Spermathecae paired in 7/8. Setae numerous. Genital markings paired in 4-9 and 18-22. Intestinal caeca absent.

Distribution: Homeland unknown: in south-east Asia (Easton, 1979: 46) or tropics of Papua New Guinea (Gates, 1972: 221); introduced records: Travencore, India; Sri Lanka; Pakistan; Seychelles; Brazil (e.g. Righi, 1967: 1999); Argentina and Mexico (C. Fragoso, pers. comm.); Oahu, Hawaii; northeast Madagascar; Suva Point, Fiji; Qld, Australia; Rarotonga, Cook Islands (new record by current author, Dec. 2002), the Botanic Gardens in Singapore (Shen & Yeo, 2005) and at Kew [Cs. Csuzdi pers. comm. 24/6/2008 in material identifiable by RJB – this they claimed as a new UK record despite an earlier 1891 Kew report (Ref.) - *Quarterly J. Microscop. Sci.* 32: 235-278]!

[A listing of this taxon in a rough guide for Japan is unsubstantiated an ignorable].

Localities: Brisbane suburbs [St Lucia, Taringa (in garden soil), Brookfield], Samford, Qld; Rarotonga, Cook Isls. (all new records) although Easton (1984) has it from Qld.

Habitat: Alluvial, sandy-loam under pasture; clay soil in garden; on surface after rain in forest litter.

Registration No.: Numerous specimens, some in ANIC.

Behaviour: Sluggish; contracts and becomes rigid when extracted or handled and ejects a sticky bright yellow coelomic fluid.

Length: 65-90 mm (contracts on preservation).

Width: 4.5-7 mm.

Segments: 118-146.

Colour: Pigmentless grey but soil and blood vessels, especially the dorsal vessel, show through epidermis; anterior faintly iridescent; clitellum white (or dark brown when worms are not producing cocoons).

Prostomium: Various from rudimentary and closed to clefted open epilobous.

First dorsal pore: 11/12 (12/13) continuous over clitellum.

Setae: Numerous, ca 66-84; retained on clitellum.

Nephropores: None.

Clitellum: Annular 14-16.

Male pores: On raised circular porophore on 18.

Female pores: Single, central within small circular depression on 14.

Spermathecal pores: 7/8 lateral.

Genital markings: Largish, paired (or unpaired), presetal on some or all of 6-12; on 18/19 a paired group then presetal on 19-21,22 usually present.

Septa: 5/6-7/8 strong; 8/9-9/10 aborted; 11/12 on weaker.

Dorsal blood vessel: Single, bifurcates dorsally over pharynx in 6.

Hearts: Large in 7, absent from 8 and 9, present 10-12.

Gizzard: Large, but not very muscular, spherical in 7-10.

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): 14-15; acaecate.

Nephridia: Meroic.

Male organs: Testes/funnels in large sacs in 10 and 11, (seminal vesicles in 11 and 12).

Ovaries: A pair, small in 13.

Prostates: Racemose with bent muscular duct.

Spermathecae: Large pair in 8, iridescence not seen in the anteriorly directed diverticula.

Gut contents: Very fine soil.

Notes: Common beside South Pine River, Samford in sandy riverbank and under adjacent pasture. Density of field populations of adults and immatures approached 100 m^{-2} (biomass ca. 100 g^{-2}). In the glasshouse this species had moderate positive influence on plant yields. Few surface casts are produced as this species is geophagous and works to considerable depth.

Polypheretima voeltzkowi (Michaelsen, 1907)

Polypheretima voeltzkowi (after Easton, 1979: fig. 17b with no known © mark).

Pheretima voeltzkowi Michaelsen, 1907: 45. [Locality Great Comoro, Comoros. Syntypes Hamburg v6936, Berlin 4946].

Metapheretima voeltzkowi: Sims & Easton, 1972: 233.

Polypheretima voeltzkowi: Easton, 1979: 47, figs. 14n, 17b; Lee, 1981: 559, fig. 25 (of a spermatheca).

Diagnosis: *Polypheretima* with simple male pores c. 0.3C apart. Length 40-69 (Easton) or 100 mm (Lee) by 2.5-5.0 mm. 85-125 segments. First dorsal pore 12/13. Setae 50-70 (Easton) or 90-140 with the ventral-most half dozen setae on 2-12 on a prominent transverse ridge (Lee). Spermathecae dorsal about 0.66C apart postsetally on 5 (or absent). Male pores simple on circular porophores 0.3C apart. GMs paired median to line of male pores, one pair on 17 and two pairs) on 18 (Easton), or just on 19-22 (Lee). Septa 5/6/7 thick. Hearts 10-12 (Easton) or 10-13 (Lee). Holandric. Psudovesicles in 13 or 14. Diverticula small, simple.

Distribution: Comoro Islands and Malekula Island, Vanuatu ex cocoa plantation.

Remarks: Easton (1979: 47) said this species was initially misdiagnosed with spermathecal pores in 5/6; he also thought this species was introduced to Comoros, possibly from New Guinea (directly or indirectly?); while Lee (1981: 559) thought it a "*Melanesian species*" introduced to Vanuatu as two specimens were found in a cocoa plantation near a village but not in the adjacent forest.

Family **Glossoscolecidae** Michaelsen, 1900

Glossoscolecidae Michaelsen, 1900: 420; Gates, 1972; 1982: 19. [Syns. Geoscolecidae Rosa, 1888: 7; Rhinodrilidae (part. *Rhinodrilus*) Benham, 1890: 222; Urochaetidae, Beddard, 1891: 261 (objective jr. syn. Pontoscolecidae James, 2012 that lasted only a week!); see Blakemore, 2012, 2013].

Type-species and genus: *Glossoscolex giganteus* Leuckart, 1835: 88.

Diagnosis: Prostates with muscular ducts lacking. Nephridia holoic (vesiculate and tufted in parts of body). Setae (often bifid) lumbricine sometimes alternating, rarely perichaetine (eg *Periscolex*). Dorsal pores seldom present. Clitellum saddle-shaped, occupies up to 12 segments from near female pores. Male pores paired behind female pores, sometimes double paired (e.g. *Eudevoscolex*) or single unpaired (e.g. *Fimoscolex*). Digestive system with an oesophageal gizzard in 6; extra-mural calciferous glands paired in some or all of 7-14 or absent. Spermathecae adiverticulate.

Distribution and diversity: About 550 nominal species forming 30 or so genera are confined to the neotropical region (tropical Central and South America from central Mexico to Peru and Rio de La Plata). One species, *Pontoscolex corethrurus* that is thought to originate in the Guayana Shield area, is widely distributed in the tropics, especially near the coast and in disturbed soils. See Blakemore (2007) for species list.

Some key genera are:

Glossoscolex Leuckart, 1835: 88 et *Glossocole*x (laps.) (Type *G. giganteus* Leuckart, 1835: 764 from Rio de Janeiro, Brazil), [Syns. *Geoscolex* Leuckart, 1841 (Type *G. maximus* Leuckart, 1841: 104); *Titanus* (Type *T. brasiliensis* Perrier, 1872: 57; *Tykonus* (Type *T. grandis* Michaelsen, 1892: 212)]. Thirty-seven species from tropical South America; the species *Glossoscolex peregrinus* Michaelsen, 1897 from the Antilles and Bolivia (where it may originate from) was transferred to genus *Glossodrilus* Cognetti, 1805: 5 (Type *G. parvus* Cognetti, 1905); (Syns. *Andioscolex* Michaelsen, 1927: 372; *Tonperoge* Righi & Ayres, 1975: 313) (see Zicsi, 1995).

Hesperoscolex Michaelsen, 1900: 421 [nom. nov. pro *Trichochaeta* Beddard, 1892/3: 252 (non *Trichochaeta* Bigon, 1878, Diptera)] (Type *Trichochaeta hesperidum* Beddard, 1893: 252) from Antilles found (e.g. by Righi, 1984) synonymous with *Diachaeta* Benham, 1886.

Rhinodrilus Perrier, 1872 [Type *R. paradoxus* Perrier, 1872 (syn. *Anteus callichaetus* Michaelsen, 1892)], [Syns. (*Thamnodrilus* Beddard, 1887 part?); *Aicodrilus* Righi, 1971 (type *A. panxin*)]. Comprises 46 nominal taxa confined to

South America with the type-species known from Brazil, Colombia, Venezuela and also found in the Caribbean, possibly by transportation (Benham, 1890: 253; Michaelsen, 1900: 431; Righi, 1990: 46; Christoffersen, 2007; and Brown & Fragoso, 2007; Blakemore, 2007).

Genera *Diachaeta* Benham, 1886, *Onychochaeta* Beddard, 1891 and *Pontoscolex* Schmarda, 1861 are described in more detail below.

Key to Peregrine Glossoscolecidae Genera

1. Setae non-lumbricine (i.e., more than 8 per segment) … ***Periscolex*** Cognetti, 1905 (type-species: *Diporochaeta profuga* Cognetti, 1904: 4). Distribution: Latin America, only one of the ten species, *Periscolex brachycystis* (Cognetti, 1904: 4) (originally *Hesperoscolex brachycystis*), widespread in Central American/Caribbean (e.g. Mexico, Panama, Cuba) thus possibly classed as a peregrine. Zicsi (1992) provides a review of the genus.

Setae lumbricine (8 per segment, often sinuous or irregular) …...…….. 2

2. Calciferous glands absent (or small); setae irregular ……..... 3

Calciferous glands large; setae often alternate/irregular in posterior 4

3. Seminal vesicles in 12 (long); setae often irregular from anterior …..…. ***Diachaeta***

Seminal vesicles in 11 and 12; setae often absent from anterior few segments and irregular in posterior ……..... ***Onychochaeta***

4. Extramural calciferous glands in 11 and/or 12 (spermathecae paired in 8/9) ..... *Glossodrilus peregrinus* (Michaelsen, 1897: 360), formerly in genera *Tykonus* or *Glossoscolex* or *Andioscolex*; introduced to Hamburg with plants from West Indies and also recorded from Bolivia (Cognetti, 1902); it is described by Michaelsen (1900: 444) and Zicsi (1995).

Calciferous glands paired 7-9; seminal vesicles in 11; setae usually alternate regularly on hindbody ..... ***Pontoscolex***

Genus ***Diachaeta*** Benham, 1886

Diachaeta Benham, 1886: 89; Beddard, 1891: Michaelsen, 1900; Christoffersen, 2008. [Syns. *Trichochaeta* Beddard, 1893: 252 (type *Trichochaeta hesperidum*); ?*Amazo* Righi *et al.*, 1976: 360 (type *Amazo nia*) – synonym by Christoffersen (2008: 4) but thereafter retained as a subgenus].

Type-species: *Diachaeta Thomasii* (sic) Benham, 1886: 89 from St Thomas, Caribbean.

Diagnosis: Glossocolecid with gizzard in 6. Calciferous glands absent. Nephridia holoic, vesiculate sphinctate. Seminal vesicles in 12 (extending to segment 38 in *thomasi*). Lumbricine (setae, except for a lines, with irregular positioning from anterior). Male pores and tubercula pubertatis in the clitellar region (22 in *thomasi*). Spermathecae present. Last hearts in 11. *D. thomasi* Benham, 1886, the type-species with 3 pairs of spermathcae, and its possible synonym *D. littoralis* Beddard, 1892 with 2 pairs of spermathecae; both endemic to shorelines of St Thomas, Antilles, Jamaica and other Caribbean Islands. Ca. 18 other species known, mostly from Brazil.

Distribution: Ca. 20 known species in Latin America and Caribbean. Often littoral on beaches (spread, at least partly, by ocean currents?). Type-species is relatively widely distributed in the region - see Michaelsen (1900: 424), Brown & Fragoso (2007: 50).

Notes: Two species previously accommodated in *Hesperoscolex* Michaelsen, 1900: 421: viz. *Trichochaeta hesperidum* Beddard, 1893: 252 [the type-species, syn *Pontoscolex trinitatis* (laps.?) Beddard, 1895a: 646] with spermathecal pores in 6/7/8/9 from Jamaica and Trinidad, and *Hesperoscolex barbadensis* (Beddard, 1892/3) with spermathecal pores in 9/10/11/12 from Barbados, were both recorded from Kew Gardens in cases of imported soil; Sims & Gerard (1985: 123) note that both species are now transferred to *Diachaeta*. The species *Hesperoscolex columbianus* (Michaelsen, 1900a: 259), originally as *Trichochaeta columbiana*, from near Bogota, Colombia, is now placed in *Martiodrilus* Michaelsen, 1936. Whereas *Diachaeta windlei* Beddard, 1890/1 was transferred as type-species of *Onychochaeta* Beddard, 1891: 259 (see Beddard, 1892/3; Michaelsen, 1900: 423).

In recent reviews, Zicsi (1995) considered *Diachaeta hesperidum* (Beddard, 1893) a synonym of *Diachaeta thomasi* Benham, 1886 however, Righi (1995) disagreed.

Key to Widespread and Classical *Diachaeta* species

1. Setae in regular ranks ..... *D. barbadensis* (Beddard, 1893) at Kew from Barbados.
   Setae mostly in irregular longitudinal ranks ..... 2.
2. Clitellum from 20-33; three pairs spermathecae in 6/7/8/9 …. *D. thomasi* Benham, 1886: 89, fig. 22-30 from St Thomas, Belize, Virgin Isles, Aruba, Curasao, Saba, Bonaire, Gran Cayman, Colombia, Panama, Jamaica, Dominica and possibly some other Caribbean islands (especially if syn. *Trichochaeta*

hesperidum Beddard, 1893 from Trinidad and *D. littoralis* Beddard, 1892 are included in synonym as per Michaelsen (1918) – see Gates (1942: 100).

Clitellum from 16-31; two pairs of spermathecae ….*D. littoralis* Beddard, 1892: 128, figs. 4-5 [syn. *Pontoscolex arenicola* (part.) Schmarda, 1861: 11 from Jamaica and possibly a junior synonym of *D. thomasi* that was originally *D. thomasii*].

Genus ***Onychochaeta*** Beddard, 1891

Onychochaeta Beddard, 1891: 259; Michaelsen, 1900: 423; Christoffersen, 2008.

[Syn. *Sporadochaeta* Cognetti, 1905: 5 (type *S. elegans*)].

Type-species: *Diachaeta windlei* Beddard, 1890: 171 from "*the Bermudas*".

Diagnosis: Glossocolecid with gizzard in 6 and paired calciferous glands in 7-9. Nephridia holoic, vesiculate. Seminal vesicles in 11 and 12. Lumbricine (setae often absent from anterior 3-5 segments and with irregular positioning in posterior). Male pores and tubercula pubertatis in the clitellar region. Spermathecae present.

Distribution: Latin America in Mexico, Brazil, Guayana, Venezuela and Caribbean (see Key below). The type-species is relatively widely distributed in the region - see Michaelsen (1900: 423), Brown & Fragoso (2007: 56), Blakemore (2008).

Key to *Onychochaeta* species [modified from Rodriguez *et al.* (2003: 90; fig. 1)]*.

1. Tubercula pubertasis in 22-26 ..... *O. serieia* Righi, 1971 from Brazil.
   Tubercula pubertasis in 19,20-22,23 2
2. Setae b, c and d irregular in post-clitellar segments ..... *O. elegans* (Cognetti, 1905) [(syn. *O. e. cubana* Michaelsen, 1923: 74) from Cuba, Panama, Mexico and Colombia - see Rodriguez *et al.* (2003) for review and figures].
   Setae all irregular in post-clitellar segments 3
3. TP on 19-21; spermathecae in 6-8 ... *O. borincana* Borges, 1994 from Puerto Rico.
   Tubercula pubertatis on 20-22; spermathecae in 7-9 .... *O. windlei* (Beddard, 1890) [originally *Diachaeta windlei* Beddard, 1890: 171; widespread (peregrine?) from Caribbean, Bermuda, Venezuela, Surinam, Cuba and (G. Brown pers. comm.) from Mexico; see Michaelsen (1900: 423); Righi & Araujo (2000) and Rodriguez *et al.* (2003) for review and figures].

**Rhinodrilus sibateensis* Michaelsen, 1900a: 247; 1900: 433 from Colombia (near Bogota) is newly transferred to *Onychochaeta* (from Brown & Fragoso, 2007: 56)

Genus ***Pontoscolex*** Schmarda, 1861

Pontoscolex Schmarda, 1861: 11; Beddard, 1895: Michaelsen, 1900: 424; Stephenson, 1930: 489; Gates, 1972: 53; Blakemore, 2002, 2006, 2008, 2012; Christoffersen, 2008. [Syns. *Eurydame* Kinberg, 1867 (type : *E. insignis*); *Urochaeta* Perrier, 1872 (type: *U. hystrix* Perrier, 1872); *Titanus*? (part.) Vaillant, 1889 cf. *Glossoscolex*; ?*Estherella* Gates, 1970: 1 (type *E. montana* Gates, 1970 from Puerto Rico) – claimed by Christoffersen (2008: 8), not accepted by other authors e.g. Blakemore (2002; 2007)].

Type-species: *Pontoscolex arenicola* Schmarda, 1861 (part, type = *Pontoscolex corethrurus*) from Port Royal shoreline in Jamaica. [Note: Schmarda (1861) confused two species under the same name without giving a type specimen, Beddard (1892: 126-129) as the first reviewer of types separated them as *Pontoscolex arenicola* (= *Pontoscolex corethrurus*) and *Diachaeta littoralis* Beddard, 1892 (= *Diachaeta thomasi* Benham, 1886); this former taxon has sometimes been wrongly placed, in part, in synonymy of *Pontodrilus litoralis*].

Diagnosis: Glossocolecid with gizzard in 6 and paired calciferous glands in 7-9. Nephridia holoic, tufted in anterior, vesiculate in intestinal segments. Seminal vesicles in 11. Lumbricine (usually alternating regularly from one segment to the next in posterior). Pigmentless. Male pores and tubercula pubertatis in the clitellar region.

Notes: Sometimes misspelt "*Protoscolex"*. Tufted nephridia are classed as "*macroic*" or as "*peptonephridia*" in some accounts. Subgenus is *Meroscolex* Righi, 1984.

Distribution: Surinam, Guyana, Guatemala, (Panama?). Just 21 species known; only the type species transported worldwide (?by oceanic drifting and/or the agency of man). A key and updated checklist mainly for natives is provided by Feijoo & Celis (2012).

Key to Widespread *Pontoscolex*

1. Setae 8 per segment but rows alternate regularly in hindbody 2

   Setae in b and d lines slightly irregular; (spermathecal pores at 7/8/9/10) .... *Po. hingstoni* Stephenson, 1931 reported from the Guayanas e.g. Lavelle & Lapied (2003).

2. Sexathecal, spermathecal pores at 6/7/8/9 or near 8/9/10/11 3

   Octothecal, spermathecal pores at 6/7/8/9/10 ..... *Po. vandersleeni* Michaelsen, 1933 known from the Guyanas and from Manaus, Brazil (Zicsi *et al.* 2001);

name sometimes misspelt “vandersleni” e.g. in Lavelle & Lapied (2003).

3. Spermathecal pores at 6/7/8/9 ..... *Po. corethrurus* (a widepread cosmopolitan species reported from tropics around the world).

Spermathecal pores posteriorly in 8,9,10 or in 8/9/10/11 ..... *Po. insignis* (Kinberg, 1867); Michaelsen (1900: 426) has this taxon with synonym *Po. lilljeborgi* Eisen, 1896 and gives its distribution as Central America (Guatemala and St Joseph Island near Panama), although Gates (1972: 54) had *Po. lilljeborgi* Eisen, 1896 separately (with spermathecal pores on anterior margins of 8-10) and he said the structure of its calciferous glands is unknown so it is possibly not a *Pontoscolex*. Fragoso & Brown (2007: 57) only listed *Po. lilljeborgi* Eisen, 1896 and appear to have missed the senior synonym of *Po. insignis*. The original description of *Po. lilljeborgi* by Eisen has its locality as “*Antigua*” – this is a city in the central mountains of Guatemala and not the Caribbean Island.

Further species, *Po. cusai* Righi, 1984 is reported from Venezuela and Brazil (Lavelle & Lapied, 2003) and *Po. cynthias* Borges & Moreno, 1990 is from Mexico, Porto Rico and Cuba (Fragoso & Brown, 2007).

The recent species from China called *Pontoscolex guangdongensis* Zhang *et al*., 1998 in Zhang, Wu and Sun, 1998: 5 cannot be a regional native in China and, if it’s even in correct genus, is probably an exotic synonym, most likely of *Po. corethrurus*.

Pontoscolex corethrurus (Müller, 1857)

Fig. 3.1 *Pontoscolex corethrurus*, Samford specimen: (a) ventral view, (b) spermathecae, (c) cocoon (near to hatching), (d) lateral view of anterior showing ‘calciferous glands’, (e) lateral view of posterior with setae in quincunx (alternating rows).

Fig. 3.2 *Pontoscolex corethrurus* Brookfield specimen: everted, proboscis-like prostomium (a) ventral view with (b) spermathecae *in situ*, (c) lateral and (d) dorsal views; (e) dorsal view of one of the three pairs of "calciferous glands", from 8, (f) ocarina-shaped nephridial vesicle.

Fig. 3.3 *Pontoscolex corethrurus* cocoons photograph (lhs).

Fig. 3.4 *Po. corethrurus* known distribution map.

Lumbricus corethrurus Fritz Müller, 1857: 13. [Type locality Itajahy (Itajai), S-E Brazil. Types not located]. [Note: date and page sometimes miscited as “1856: 26” or “1857: 113”. In the same paper, Schultze (1857: 6) gives Müller’s description of a planarian living in the heavy clay soils with this species which Müller said was

the commonest worm in Brazil, "*found in every clod of arable land*"].

Urochaeta hystrix Perrier, 1872: 142, figs. 85-88. [Types in Paris].

Urochaeta corethrura: Perrier, 1874: 379.

Pontoscolex arenicola Schmarda, 1861: 11 (part, type), fig. 157. [From tidal beaches Port Royal, Jamaica; the name 'arenicola' or 'harenicola' translates as "*sand or beach-loving or dwelling*". Types in Vienna Museum]; Beddard, 1892: 126, figs. 3 & 6. [Note: Schmarda (1861) confused three species under the same name without giving a type specimen although his figure (fig. 157) was the same as the specimen that Beddard (1892: 126, figs. 3, 6) separated as *Pontoscolex arenicola* (= *Pontoscolex corethrurus*), the other he named *Diachaeta littoralis* Beddard, 1892 (= *Diachaeta thomasi* Benham, 1886)].

Urochaeta dubia Horst,1885: 7. [Type locality Sumatra. Types lost].

Urochaeta, *sp*. Beddard, 1887: 160, Pl V, figs. 4-9 (= *P. corethrurus*). [Specimens collected by Mr S. Prout Newcombe from Queensland – slides in BMNH?].

Urochaeta australiensis Beddard, 1891: 278 nom. nud. (Beddard footnote: "I have not yet described this species, but I believe is to be distinct from *U. corethrurus*"). [Queensland, Australia. Specimens (syntype slides? in BMNH 1904:10:20: 1148-55].

Pontoscolex hawaiensis Beddard, 1895a: 660; 1896: 186. [From Mauna Loa, Hawaii. Types missing]; Beddard, 1900: 414 (syn.of *corethrurus*). [Sometimes misquoted as "*hawaiiensis*" and miscited as "*Beddard, 1896*" which is Beddard's 1896: 196 mistake of redescribing *hawaiensis* twice!].

Pontoscolex corethrurus mexicanus Eisen, 1896: 8. [From Mexico. Types missing]; Eisen, 1900: 87, figs. 1-37 [inadvertently (re-)described as "subsp. nov."; from Baja California, through Mexico, Guatamala to Salvador in Central America].

Pontoscolex (*Urochaeta*) *corethrurus*: Beddard, 1892: 128.

Pontoscolex corethrurus: Beddard, 1892b: 127; Michaelsen, 1900: 425 (syn. *mexicanus*, *hystrix*, *dubia*, *australiensis*, *hawaiensis*); 1916: 21; 1918: 234; Stephenson, 1916; Gates, 1943: 92; 1954: 219; 1972: 53-58 (syn. *arenicola*); 1982: 19 (syn. *arenicola, mexicanus*); Sims & Gerard, 1895, 1999: 124, fig. 44; Lee, 1981: 568; Easton, 1984:120; Blakemore, 2002; 2006; 2008; 2010.

Pontoscolex (*Pontoscolex*) *corethrurus*: Righi, 1984: 163.

Pontoscolex guangdongensis Zhang *et al*., 1998 in Zhang, Wu and Sun, 1998: 5. [Guangdong. Types?]. **Syn. nov.?**

Taxonomic Notes: There is some conflict with the orginal citation as Michaelsen (1900: 425), Lee (1981) and Gates (1973) have 'Müller (1857: 113)', but Gates (1972: 53), Reynolds & Cook (1976) and Sims & Gerard (1985; 1999) have 'Müller (1856: 26)', while Easton (1984) has 'Müller (1856: 113)'; actually it is 1857: 13 (pers. obs.). Sometimes misspelt "*corenthrurus*".

Author is Fritz Müller, not Danish naturalist Otto Friedrich Müller (1730-1784).

Diagnosis: Body pigmentless; clitellum pale or yellow saddle-shaped in 15-22,23. Setae 8 per segment; in the posterior part of the body in quincunx (alternating regularly from segment to segment). Three pairs of calciferous glands visible through the cuticle in front of clitellum. Prostomium 'proboscis-like'. Spermathecal pores at 6/7/8/9. Female and male pores difficult to locate (in 14/15 and 19/20 or 20/21, respectively).

Distribution: Pan-tropical; supposedly "*the most widely distributed earthworm*" (Gates, 1972: 55). E.g., Sabah (Padas Valley by Beddard, 1895) also Sarawak north Borneo (although Michaelsen, 1916: 21 recorded this species from Labuan off Borneo, the new record for Borneo is below), Maros karst area of Southern Sulawesi (Ref.), Myanmar, Thailand, Vietnam (abundant in "*hilly soil*"), Laos (Thai & Samphon, 1989), Cambodia (from elevation of 1,100 m: Michaelsen, 1934), Taiwan and Lanyu Island, Hong Kong, Malay Peninsula and Singapore (botanical gardens - Michaelsen, 1916: 21), Penang; Sumatra, Java, and Bali (**new record** for Indonesia; collected by RJB 28th Sept, 2010 under rocks and coconut husks widely dispersed around Ubud), Christmas Island south of Java (Michaelsen, 1935a; Gates, 1935b), Celebes, Moluccas, Philippines (e.g., Manila - Gates, 1943: 92 – new record from Kahariam farm Lipa City by RJB, 13.V.13), New Caledonia, Loyalty, Solomon, Vanuatu, Fiji, Tonga, Tahiti, Samoa (e.g. Cognetti, 1909; Easton, 1984), Marquesas, Hawaii, USA*, Mexico, Guatemala, Honduras, Salvador, Nicaragua, Costa Rica, Panama (Michaelsen, 1916: 21), Colombia, Ecuador, Brazil, Paraguay, Surinam, Guyana, Venezuela, West Indies, St. Barthelemy (Michaelsen, 1916: 21), Trinidad (e.g. on summit of Mt Tucouche, just over 3,000ft, collected along with *Rhinodrilus crutus* Stephenson, 1931), Azores, Bonaco, Martinique, Dominica, St Thomas, Puerto Rico, Haiti, Guadeloupe, Cuba, Cape Verde, Algeria, Liberia, Congo, Tanzania, Natal, Kenya, Madagascar (e.g. Michaelsen, 1901), South Africa, Mauritius, Madagascar and Comoros Islands, Mahe Seychelles, St Helena, Iran, Pakistan, Bangladesh, India, Sri Lanka, India, England (Kew Gardens from, amongst other places, Mauritius – Beddard, 1892: 170); also Australia (Stephenson, 1933, Blakemore, 1994; 1996; 1999), South Africa (Plisko, 2001), and Yona, northern Okinawa, (collected by

RJB on 20.xi.2005 from soil by drain in *Castanopsis sieboldii* forested hills above Ryukyu University Forestry Research Centre, Yona (ca. N26°45′, E128°05′) – see Blakemore *et al.*, 2007a). **New record for Okinawa, Japan** although Nakamura (1994) reported it from Ogasawara (= Bonin Islands) 1,000Km south of Tokyo. Specimens also identified by the author (all new records) from Rarotonga, Cook Islands; Galapagos Islands (pers. obs. from Santa Rosa, San Cruz, collected M. Mantilla/M. Nakamura, 1994-VII-4); and from *Acacia mangium* plantation 50 Km from Kuching, Sarawak Malaysia in density up to 300 m^{-2} to 30 cm; and lowlands near Mt Kinabalu – both on Island of Borneo (samples from YNU students, IDed by RJB in 6.IV.2004 and 2005; see Blakemore *et al.* (2005). Michaelsen's (1900: 426; 1903: 132) reports from **New Zealand** had been overlooked, but it is not subsequently confirmed (see Blakemore, 2010, 2011; 2012). However, note that Cognetti's (1909) report from "Isole Samoa" may apply in part to Tokelau group of islands too and these are under NZ aministration.

*Gates (1954: 221) says first continental USA species were from Chatham, New Jersey, in greenhouses on Southern Boulevard, October 24, 1947, but introduced 10 years earlier at least (i.e., <1937). These worms damaged the nursery beds there.

Localities in Australia: Qld: Brisbane (suburbs of St Lucia, Taringa, Brookfield); Samford; Kingaroy; Eumundi; Gayndah; Mundubbera; Biloela; Cardwell; Tully in tropical north Qld. In NSW, obtained from Harwood in the north-east and from the Botanic Gardens, Sydney (pers. obs. RJB) – these new NSW records represent the most southerly distribution of this generally tropical species in Australia.

Habitats: Wide range of soil types and environments, in all but very dry soils from which they retreat, especially abundant in moist soils; found just above water-line in a riverbank (South Pine River, Samford); under sugar cane at Harwood, NSW; "*in pasture and common in sugarcane soils, Tully N. Qld.*" (L.N. Robertson pers. comm.). Under taro, in gardens and besides creeks from coast to mountains on Rarotonga, Cook Island.

Classed as geophagous, topsoil or subsoil (endogeic?) species, eurytopic; its common occurrence in coastal areas suggests marine transportation (by drifting?) and euryhalinity, in fact as early as 1895 Beddard suggested this (Beddard, 1895: 149). Its close association with rivers also indicates a possible mechanism of transportation (of cocoons). Human mediated transportation is probably also important (see Remarks below).

Found to have a preference for sandy soil rather than clay soil in choice chamber expeiments (Blakemore, 1994).

Registration: ANIC, numerous mainly Queensland specimens collected throughout the year whenever the soil was moist. Okinawan specimens in YNU Soil Ecology Lab.

Behaviour: Contracts when touched and posterior may become bulbous, clear coelomic fluid ejected. When relaxed the worm everts a probing proboscis from the peristomium and the body length can be three or four times its contracted state. Autotomy; diapause (Gates, 1954; 1972).

Lengths: 60-142 mm (from 46 mm Gates, 1982: 19; Stephenson, 1931b: 84, to 360 mm).

Width: 4-6 mm.

Segments: 166-250, some secondary annulation. Anterior and posterior segments rugose. The first setigerous segment is counted as '2' (but it may actually be 3).

Colour: Unpigmented, anterior yellow/pink, three pairs of flattened, white "calciferous" glands enveloped in red capillaries are often visible through cuticle just anterior to clitellum; the clitellum is variously white or yellow/orange; white chloragogen cells surround gut and soil in the gut is often visible; dorsal blood vessel clearly visible.

Prostomium: Pointed, usually retracted on preservation (see illustrations).

First dorsal pore: None.

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment (from segment '3', here designated as 2), closely paired widening over clitellum thereafter migrating to assume quincunx arrangement (setal rows alternating) in posterior; on segment 7 (9:1:5:1:22:0.5).

Nephropores: Near intersegmental furrows at anterior of each segment from about 4/5/6, slightly median to setal c lines or more lateral.

Clitellum: Saddle shaped, 15-22,23.

Male pores: Not clearly defined, possibly minute at 19/20 lateral of b lines (or ?20/21 in b line, Gates, 1972).

Female pores: Minute possibly in 14 in front of ab (?14/15 in ab lines).

Spermathecal pores: Minute in 6/7/8/9 in setal c lines.

Genital markings: Translucent tubercula pubertatis ridges lateral on 19-21 framing the ventral setal couples; some setae in genital tumescences e.g. 14, 19-22.

Septa: Septa 3/4 contains the pharyngeal bulb, 4/5 and 5/6 are membranous: 4/5 contains tufted nephridia, 5/6 is possibly adherent on 6/7; 6/7 thick to base of gizzard, 7/8 and 8/9 also thick; 9/10 absent (or adherent on 10/11, Gates); 10/11 thick and displaced rearwards as are several anterior septa; from 11/12 on, membranous.

Dorsal blood vessel: Single, bifurcates at gizzard in 6 [note Beddard's *hawaiiensis* is stated to have dorsal vessel doubled for a certain extent, as was described for Eisen's

mexicanus by Eisen (1900: 106)].

Hearts: Commissurals in 7 and 8; 9,10 contain a thin pair of lateral vessels; 11 and 12 have strong pairs of hearts. The dorsal vessel in the region of 11-14 is much enlarged (and Beddard, 1896 found it doubled in this area in a few of his Hawaiian specimens). Blood vessels supply the calciferous glands in 6-9 ventrally and, in 12 and 14, small vessels pass to the oesophagus (supra-oesophageal vessel not found).

Gizzard: Spherical and muscular in 6.

Calciferous glands: Three pairs of flattened, lingular 'calciferous glands' lateral on oesophagus in 7-9 (visible through cuticle as white glands surrounded by capillaries but appear further back due to displaced septa).

Intestine origin (caeca, typhlosole): 16; typhlosole present (from 21?).

Nephridia: Pharyngeal tufted nephridia in anterior in 4 (and 5?) then holoic with, in the intestinal region, a pair of very large ocarina-shaped terminal vesicles per segment.

Male organs: Testes/funnels in 11 (? not clear), an elongate pair of saccular seminal vesicles in 12.

Ovaries: Not found (in 13).

Prostates: None.

Spermathecae: Three pairs, in 7-9 (same segments as 'calciferous' glands), each a flattened disk or flask entally on a long duct, transparent, adiverticulate.

Gut contents: Fine soil.

Notes: The anterior segments are usually retracted and the genital pores obscure, thus segment miscounts are common in some descriptions. Dissection of the anterior revealed that what may be the actual 'first' segment, bearing a prolobous prostomium, is much reduced and telescoped into a rugose, asetigerous segment that is strictly the 'second' segment. The 'third' segment then is setigerous. In this account, this first setigerous segment is counted as 2; (to conform to conventions for more normal species, one may be added to the counts above).

The 'calciferous' glands did not react in hydrochloric acid and their function is unknown, but they resemble somewhat the ocnerodrilin diverticula. They are vascularised pouches composed of numerous columnar cells but lack the lamellae, internal lumina and carbonates of calciferous glands proper.

Cocoons, the size and shape of pearls, variously transparent, white or pink (when near hatching) were frequently abundant individually, in small chambers near the soil surface (digging usually located one or more mature specimens in the vicinity).

Spherical with high turgor pressure, they rebound from flat surfaces and roll if dropped. Gates (1972: 58) comments that an infestation of *corethrurus* cocoons by enchytraeids (possibly these were nematodes?) resulted in sterility.

Regeneration of both anterior and posterior segments was noted in the field and in culture stocks during the present studies: active posterior regenerates were frequently encountered whereas anterior amputees usually remained coiled and quiescent for several weeks. Gates (1972: 57) remarks that anterior regeneration is slow.

Glasshouse trials conducted in this study (Blakemore, 1994; 1997) on this species gave variable plant yield responses and soils were sometimes compacted. However, survival and reproduction were sustained in a variety of soil types. Proposed investigations of the survival of cocoons in sea water (to determine possibility of oceanic transportation) were considered but not yet completed.

Many studies have been published on this widely distributed, abundant and peculiar species. It is supposed to be the most commonly encountered worm in several localities e.g. parts of Myanmar and Brazil. "*Overpopulation*" by this species was thought to have caused unfavourable effects on soil characteristics in greenhouses and cultivated fields (Stephenson, 1930; Gates, 1954; 1972; Puttarudiah & Sastry, 1961), although there are favourable reports too (e.g. Lavelle *et al.*, 1987; Spain *et al.*, 1990).

In New Guinea, feeding experiments showed pigs to have a preference for *P. corethrurus* compared with native species, when the protein content of their diet was supplemented with earthworms (Sims & Gerard, 1985: 124).

Sillitoe (2003) "*Managing Animals in New Guinea*", reports findings on earthworms there, including *Pontoscolex corethrurus*, that: "*Goyay* or *Pob* or *Ayaend*" means earthworms that he identifies (correctly?) with these names: *Amynthas zebrus* (Benham), *Polypheretima elongata, Metapheretima senantensis, Metapheretima tamiensis* (group), *Metapheretima oinakensis* (Group), *Pheretima Montana, Pheretima darnleiensis, Metapheretims annulata* (Group), *Pontoscolex corethrurus, Amynthas morrisi* (Group). These are found mostly in soil but "*Some worms are found up trees – in forks, large crevices and some crowns e.g. of pandans) – where rotted leaves give soil-like mould*". Worms are abundant and, according to the Wola people they are not a signal of soil productivity, particularly for their staple sweep potato cultivation (Rose & Wood, 1980). The name "*Goay-haez*" means 'white worms' for their pale colour (= *Me. annulata*). "*Goay-tomb*" is claimed to be "*Amynthus morrisi*" (sic) and "*This worm can grow very large, as thick as a man's*

finger and [as] *long as an arm*". Thus is probably a mistake. "*Senis-gogay*" or 'change worm' is "*newly arrived exotic species (Pontoscolex corethrurus). According to the Wola the presence of this foreign earthworm is evidence of particularly poor soils. Pigs relish them and very quickly grow big by eating them, developing a thick layer of subcutaneous fat. It is easy to identify areas invaded by these recently arrived worms because only they throw up casts, called gogay iy (lit. worm excreta).*"

Remarks: There are conflicting reports on the anatomy of parthenogenetic *Pontoscolex corethrusus*, and its morphology is still not fully resolved (eg. see Gates, 1972; Borges, 1992). As noted in this account, the complex cephalisation, septal irregularities and reduction of reproductive organs contribute to this confusion.

The original homeland is in "*Guayanian Shield*" area of northeastern South America e.g. Gates (1972) or Sims (1980: 117) and the latter author states: "*The now ubiquitous euryhaline* Pontoscolex corethrurus *(Glossoscolecidae) from northeastern South America is found on or near many tropical and subtropical beaches around the world together with species of* Pontodrilus*… whose origins are unknown, both seemingly are rafted around the tropics*". Mechanism of wider distribution for both species, at least initially, is possibly by transportation in ship' sand ballast and secondarily by rafting of cocoons that may be euryhaline, or perhaps adults in root boluses of logs (Blakemore, 2007b and in prep.). Initial introduction to Kerala state in India was thought related to the Portugese import of Cassava (*Manihot esculenta*) in the 17th century (Michaelsen, 1910) and may account for even earlier redistributions in America, Aftrica and Asia.

The record by the current author from Yona in northern Okinawa was from a forested region, although there were access roads to the mountains, some military installation and forestry activity (clearcutting) in the vicinity. An adjacent coop was recently felled and it is entirely possible that the heavy machinery used in recent times contributes to dispersal of this species' cocoons into more remote forest areas.

Family **Eudrilidae** Claus, 1880, em. Blakemore, 2013

Eudrilidae Claus, 1880: 479; Vejdovsky, 1884: 63; Beddard, 1890: 221; Benham, 1890; Michaelsen, 1900: 378; Stephenson, 1930: 863; Gates, 1972: 50; Blakemore, 2013.

Type-species and genus: *Eudrilus eugeniae* (Kinberg, 1867); *Eudrilus* Perrier, 1871.

Diagnosis (after Gates, 1972): Lumbricine. Holoic. Gizzard(s) present, single oesophageal or multiple intestinal. Sperm ducts pass into characteristic euprostates - digitiform glands with muscular walls. Seminal vesicles, trabeculate. Spermathecae, behind testis segments. Clitellum multilayered. Metagynous. Ventral oesophageal sacs unpaired (e.g. *Eudrilus* Perrier, 1871; *Polytoreutus* Michaelsen, 1890: 24) [sometimes mispelt "Polytoreutes" or "Polytereutus" – see Sims (1982), Blakemore (2013)] or paired [e.g. *Agrotoreutus* Segun 1976; *Parapolytoreutus* Segun, 1980 (misspelt "Parapolytoreutes"), etc.]. Dorsal pores usually absent, rarely present (e.g. in some *Platydrilus* and *Eudriloides* according to Gates, 1972: 52).

Distribution & diversity: Tropical and subtropical Africa; ca. 365 known taxa with more than 200 synonyms (Ref.); one species anthropochorous and pan-tropical. Species recorded as imports into Kew Gardens by Beddard (1891; 1893; 1897; 1906) were *Eudrilus eugeniae*, *Eudriloides durbanensis*, *Heliodrilus lagosensis*, *Hyperiodrilus africanus* and *Iridodrilus roseus* (types in BMNH), all but the first having single median male and spermathecal pores. Of these, only *E. eugeniae* has been subsequently confirmed outside of Africa and the others were not therefore considered as "*British-occurring*" by Sims & Gerard (1985; 1999: 145), although Michaelsen (1910) classed *Hyperiodrilus africanus* as peregrine.

Chuniodrilus spp are mostly from Cote d'Ivoire, but an isolated (neoendemic?) Cairo species, now in *Stuhlmannia*, was noted by Ghabbour (2009) as: *Ch. ghabbouri*.

Notes: Sometimes separated into two sub-families: Eudrilinae and Pareudrilinae Beddard, 1894 and now Polytoreutidae Blakemore, 2013 [also mentioned in litt. by E. Perrier (1925: 165)]*. Monospecific Hippoperidae was dubiously errected (by Taylor, 1949) for a eudrilid, *Hippopera nigeriae*, supposedly distinguished by a second pair of male pores (Gates, 1959: 257) although two other taxa have since been found by Segun (1978) in Nigeria. Eudrilids are the most morphologically (and genomically?) 'advanced' earthworms according to Gates (1982: 71) as some species having direct, internal fertilization via spermathecal pores modified as effective vaginas. Such adaptation is unknown and probably functionally impossible in other megadriles. Sims (1987) proposed the reproductive organ modifications were to thwart gregarines.

*[Note: The citation in the translantion of Perrier (1925) for the passage:
"The most salient leech characters appear in certain Central African Worms, the **Polytoreutidae** [1], in which, as in Leeches, the reproductive orifices are placed in a median ventral line instead of according to the usual symmetrical arrangement."
Footnote [1] for "Polytoreutidae" is "LXXII" which leads to a citation (here corrected) of :

Pereyaslawzewa, *Sophie* (1901). *Developpment embryonnaire* des *Phrynes*. Annales des sciences naturelles, zoologie (8) 13: 117-304. [http://archive.org/stream/annalesdesscie8131901miln/annalesdesscie8131901miln_djvu.txt].

This reference has no such name thus this citation must be both dubious and out-of-date for ICZN validity so it is probable Polytoreutidae Blakemore, 2013 yet stands].

Key to Peregrine Eudrilidae, OP - oesophageal pouches, Ca - Calciferous (glands)

OP unpaired in 10 & 11, paired Ca glands in 12; single oesophgeal gizzard….. *Eudrilus*

OP unpaired in 9-11, paired Ca glands in 13, several intestinal gizzards…. *Hyperiodrilus*

OP and Ca glands absent; gizzard in 5 or 6 … *Eudriloides* Michaelsen, 1890; e.g., *E. durbanensis* Beddard, 1893: 696 ex Kew from Durban (Michaelsen, 1897; Zicsi, 1997).

Genus ***Eudrilus*** Perrier, 1871

Eudrilus Perrier, 1871: 1175; Benham, 1890; Michaelsen, 1900: 401; Stephenson, 1930: 881; Gates, 1972: 51; 1982: 72; Sims & Gerard, 1985: 145; Blakemore, 1994, 2002, 2012.

Type-species: *Eudrilus decipiens* Perrier, 1871 [= *Lumbricus eugeniae* Kinberg, 1867].

Diagnosis: Oesophageal gizzard present (near 5?), ventro-median calciferous gland in each of 10-11 and in 12 a pair of lobular glands. Hearts 7-11. Ventral setae of 17 lacking.

Distribution: Mainly confined to tropical west Africa, but the type is circummundane in tropics (in lowlands at least) by introduction - this species is widely cultured in the Americas and Australia as live bait for fishing and in Asia for vermicomposting. The supposed occurrence in N.Z. was refuted by Lee (1959: 369). This is the first record for Australia, for once, confirming a worm grower's species claim.

Notes: Species that are possibly close to *Eudrilus eugeniae* are *Eu. pallidus* Michaelsen, 1891 [non *Eodrilus pallidus* Lee, 1959 (now in *Diplotrema*) - an Acanthodrilidae from New Zealand] and *Eudrilus simplex* Michaelsen, 1913 - see Gates (1972: 51).

Eudrilus eugeniae (Kinberg, 1867)

Fig. 4.1. *Eudrilus eugeniae* (a) ventral view of Qld specimen, (b) vasa deferentia unite to form the muscular euprostates leading to the copulatory chamber, (c) spermathecal aperture and combined ovary (with oviduct unravelled), (d) prostomium, (e) calciferous glands, hearts and dorsal vessel, (f) dorso-lateral view of caudal segments narrowing to pygomere. np = nephrophores.

Lumbricus eugeniae Kinberg, 1867: 98. [Type locality humid mounts and valley of St Helena Island (British protectorate) in South Atlantic, by introduction. Types from Stockholm Museum now seemingly transferred to Natural History Museum London by Beddard and sometimes quoted as BMNH 1904.10.5.549 [that is actually Kinberg's *L. capensis*] or 1904.10.5.550 – the latter specimen now with labels saying: "*Lumbricus eugeniae Kinberg 1867 TYPE sent to Dr Beddard by Professor Loven. St Helena*", Beddard's label with "*Lumbricus*" crossed out in favour of "*Eudrilus*"; and a Swedish Museum label: "*Lumbricus Eugeniae Kinberg St Helena Swed. State Museum*." The specimen is coiled and seems a bit macerated but looks in moderate condition – pers. obs. RJB VI.2013. Not inspected further in order to preserve the type specimen's integrity].

Eudrilus decipiens Perrier, 1871: 1176; 1872: 78; Horst, 1887: 251. [From Antilles. Types in Paris].

Eudrilus lacazii + *peregrinus* Perrier, 1872: 75,77. [Martinique (1826) / Rio de Janeiro (1833), respectively. Types in Paris].

Eudrilus boyeri Beddard, 1886: 302. [New Caledonia. Types BMNH 1904:10:5:612].

Eudrilus sylvicola Beddard, 1887: 372. [British Guayana. Types BMNH 1904:10:20:408].

Eudrilus jullieni Horst, 1890: 225. [From Liberia? Types?].

Eudrilus roseus Michaelsen, 1892: 224. [From Caracas, Venezuela. Types Humboldt Museum, Berlin 2162. Michaelsen notes "?*Eudrilus perigrinus* E. Perr." (sic)].

Eudrilus erudiens Ude, 1893: 71. [Bermuda. Types?].

Eudrilus eugenia : (laps.) Michaelsen, 1898: 144.

Eudrilus eugeniae: Beddard, 1895a: 604; Eisen, 1900: 136, figs. 27-50, 95-97; Michaelsen, 1900: 402 (syn. *decipiens* ; *lacazii* + *peregrinus* Perrier, 1872; *boyeri*; *sylvicola*; *jullieni*; *roseus*; *erudiens*); Stephenson, 1923: 486; Gates, 1942: 137; Gates, 1972: 51; 1982: 72; Sims & Gerard, 1999: 146, fig. 52; Sims, 1987: 386; Blakemore, 2002, 2010, 2012, 2015.

Note 1: Named after Johan Gustaf Hjalmar Kinberg's Swedish survey ship, '*Eugenie*'.
Note 2: A commercial worm grower in Philippines uses "Angels of the Earth" as a trade name to sell *Eudrilus* and admits (http://earthwormsanctuary.blogspot.jp/) this comes from "Australian Museum, 2003", but actually this is my article and an earlier reference is quoted in Coleman & Crossley (2004: 2) as being from "Blakemore, 2002". Filipino growers have also adopted my "VermEcology" name, which I take as a kind of tribute.
Distribution: From Michaelsen, 1903: 122; Gates, 1942: 98, 1972: 52, 1982: 72, etc.; also from DriloBASE data (Ref.), Blakemore (2015) and pers. obs.: West African origin from Upper Guinea plain or coastal forest including Sierra Leone, Liberia, Ivory Coast, Ghana, Togoland, (Benin), Nigeria, Cameroon, Gabon and the Congo; transported and peregrine in many tropical countries such as Madagascar and the Comoros Islands, Seychelles (Ref., 2010; Gerlech, 2011: 62), Andaman & Nicobar Islands (Ref. 2008: 126), Sri Lanka and India (e.g., Michaelsen, 1903; Stephenson, 1923: 486 and, more recently, Dhiman & Battish, 2005), New Caledonia; Americas, North [e.g., Gates (1982: 74) said it owes its North American distribution since 1950s *solely* to the fishing bait market having been shipped into every one of the lower 48 United States, e.g., to Florida, Alabama, Georgia, Texas, even to Hawaii, as well as several Canadian Provinces]; Central and South America, e.g. Suriname (Horst, 1887), Panama [from 1896 – e.g. Eisen (1900: 135): "*Judging from the number of specimens in the collection, this species must be the most common of the large terrestrial earthworms in Panama*" – however this I think is only from the delivered sample, perhaps collected from a compost heap, and not from any kind of quantitative ecological study in Panama], Mexico (Rodriguez, 1999), Venezuela, Guayana, Colombia (Feijoo *et al*., 2004), Paraguay (C. Mischis, pers. comm.), Belize (also as an introduction from the then 'British Honduras' noted by Gates, 1982), Brazil (Righi, 1968); Caribbean: e.g. Antilles (Gates, 1942: 99), Trinidad, Martinique, St Thomas, St Croix, Puerto Rico (Gates, 1954; Borges *et al*., 2003), Cuba (Michaelsen, 1934), Bahamas, Bermudas (e.g., as *E. erudiens* also Michaelsen, 1902, 1921), Virgin Isls. and Haiti (Michaelsen, 1903, 1907?; Gates, 1942) and Guadeloupe (Csuzdi & Pavlicek, 2009. – who found it in a natural setting indicating it may have become feral there); and Atlantic at St Helena (type-locality by introduction), Cape Verde, Fernando Po (Bioko) and Sao Tome Islands (Michaelsen, 1903, 1910).

Plisko (2010) noted that it was deliberately introduced to South Africa (RSA) by Reinecke & Viljoen (1988) from Germany in stock originating in West Africa, possibly

the same as for the Philippines source, and that this species is now widely used in RSA farms and is "*adapting well to habitats in this country*" suggesting naturalization.

Stated to be one of four vermicomposting species newly introduced to Egypt from Australia (Medany, 2011: 20). What this paper actually says is: "*Four types of earthworms were brought to Egypt from Australia. from Australia:* Lumbriscus Rubellus *(Red Worm),* Eisenia Fetida *(Tiger Worm),* Perionyx Excavatus *(Indian Blue), and* Eudrilus Eugeniae *(African Night Crawler)*", however *Lumbricus rubellus* Hoffmeister, 1843 has never been proven to be a composting worm (Blakemore, 2002), thus it is likely only three species or fewer were involved. At least one (uncontactable) worm farmer in Valparaiso, Chile and a technician (Reinaldo Plasencia) in Nicaragua claim to rear *Eudrilus*, sometimes misspelled "Fudrillus spp", (refs. http://www.lombricultura.cl/index.php?id=240; monografias.com/trabajos12/mncuarto/mncuarto.shtml) which would both be new national reports. Sr Enzo Bollo Tapia informs me (email 3rd July, 2014) that it can be cultivated in Ecuador, Colombia and Peru but that Chile is unsuitable for its survival, although he did experiment there. Introduced into Philippines for vermicomposting in the 1980s (a report of spread to some mountainous inland areas via agro-forest strips of Negros Occidental by Flores, 2007 is unsubstantiated as there is no proof that *Eudrilus eugeniae* itself was found, the report just says "*Eudrilus*" based on a novice's key to families). Also reported from Thailand from an unpublished DNA barcode submission in 2010/2011 and a recent vermicompost report from there (Ref. 2013 and see Appendix) and vermicomposting of rice husk and soy bean residues from Malaysia (Ref1, Ref2, Ref3) with worms apparently imported as cocoons from Indian and from Indonesia where vermiculture operations in Solo, Central Java are advertized (e.g. http://www.indonetwork.net/tradeoffers/15/lumbricus.html ; http://cacinglumbricus.wordpress.com/), also from the Animal Husbandry Faculty for vermiculture at Bogor Agricultural University, West Java (Andy Darmawan pers. comm. Nov. 2014).

Introduced to Hamburg with plants from the West Indies (Michaelsen, 1903: 12) and to Kew Gardens (in Wardian cases from British Guiana according to Beddard, 1906), and New York from Cape Verde (Gates, 1982); rarely reported from greenhouses in northern Europe by Sims & Gerard (1985), e.g., as from Denmark (Anon. 2007) and Hungary (Csuzdi *et al.*, 2007); maintained in some laboratory cultures, e.g., in Vigo, Spain (Dominguez *et al.*, 2001).

New Zealand records by Beddard (1895: 149), repeated by Michaelsen (1900, 1903), Hutton (1904: 355), Gates (1972) and Sims & Easton (1985) was stated by Thompson (1922: 359), Benham (1950) and Lee (1959: 365) to be an error introduced when Beddard (1891; 1895: 149) somehow mistook Smith's 1886 report of *Endrilus* [sic lapsus for *Eudrilus*] *levis* [= *Octochaetus*? *levis* (Hutton, 1877)] from Taranaki for *Eudrilus eugeniae*. Recent personal surveys of vermicomposting operations in New Zealand also failed to locate this species there (Blakemore, 2012a).

The report from French islands off the coast of Newfoundland (St. Pierre and Miquelon) of *Eu. lacazzi* by Perrier (1872) were doubted by Gates (1982: 72) although this is possibly his mistake as its type-locality is Martinique not Miquelon. Elsewhere in North America, Gates (1982: 72-74) explained in some detail how the first report from the mainland was in 1950 from "Lake Geneva, Florida" was from a "*can of worms (bait) inadvertently left behind*" and cultured by the camp owner (a Mr T. Baker) and eventually being shipped to all USA and Canada where it has been cultured both indoors or outdoors.

First Australasian taxonomic confirmation from near Brisbane, Queensland in 1991 (Blakemore, 1994, 1999) with stock (cocoons) originally obtained from Canada (Mr G. Bosanquet pers. comm. to RJB in 1991). No records from Germany (supposed source of worms in Philippines and South Africa), nor Vietnam and neighboring southeast Asian countries such as for China/Taiwan, for example, can yet be found.

Found in compost at Indore MP, the site of Sir Alfred Howard's organic farming research station along with Indian native *Lennogaster pusillus* and Asiatic *Amynthas alexandri* and *Metaphire houlleti* (RJB pers. obs. March, 2016).

Locality: Specimens collected from worm farms in Brisbane (1991/2) and samples send to author for ID from Mackay in Qld (ca. 1992), and Menai, NSW (ca. 1996/7) (now in ANIC) and from Ghana and Indonesia; also confirmed from lowland Philippines (RJB, pers. obs., 2009-2014) and India in 2016.

Habitat: Originating is shaded savannahs of West Africa, also in worm beds, worm farms, compost; reported in natural high moisture/organic matter sites such as waterfalls or riverbanks on Guadeloupe (Ref.), agro-forest strips of Negros Occidental (reported by Flores, 2007 - Ref. but this not confirmed by author's surveys on this Island) and also in gardens or vegetable / fruit fields in South America (Brown & Fragoso, 2007: 372).

Registration No.: Numerous Qld specimens in ANIC, Canberra (in Ethanol).

Behaviour: Active with rapid escape response when disturbed; if captured, they become

placid and can be readily handled. Will wander, especially at night, leaving plant pots and escaping unsealed containers.

Length: Complete matures, 90-185 mm (pers. obs. and Gates, 1972) or up to 250-400 mm raised under controlled conditions (Vilijoen & Reinecke, 1994; Parthasarathi, 2007); posterior tapers and becomes thinly flattened, producing the characteristic casts and due to a terminal segmental 'zone of growth' according to Gates (1982).

Width: Ca. 4-8 mm.

Mass: 1.0g (mean per adult, pers. obs.) or up to 5-6g per worm maximum (Vilijoen & Reinecke, 1994; Parthasarathi, 2007).

Segments: 161-211 (pers. obs. and Gates, 1972) or 250-300 (Vilijoen & Reinecke, 1994 suggesting that larger worms add segments); constriction of 40-46 seen in several Qld specimens may be due to preservation effect or some artefact.

Colour: Red-brown dorsum, anterior bright blue/green iridescent, ventrum beige, clitellum dark (sometimes lighter) brown, posterior colour faded.

Prostomium: Small, open epilobous.

First dorsal pore: None.

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment from 2, closely paired, setae a and b on 17 absent; (6:1:5:1:10:0.5). Penial/genital setae absent.

Nephropores: Just behind anterior furrow of each segment (longitudinal slits) from 3/4 in c lines or slightly more median (sometimes in d lines).

Clitellum: 13, 14, 15-18,usually 13, 14-18 and interrupted ventrally.

Male pores: In 17 on tips of longitudinally grooved, tapering, eversible penes in large ventral chambers retracted as lateral slits with wrinkled lips reaching 17/18, just anterior to 17/18 in line with b setae. Note: in life, slight pressure will cause eversion of white penes that are shaped similar to a scorpion's stinger (what Eisen and Gates call "*Y-gland porophore*" that is grooved nearly to the tip).

Female pores: Combined with modified 'spermathecal pores' (see Fig.) laterally on 14.

Spermathecal pores: Paired, lateral, presetal in 14 as raised ventrally intrasegmental openings just anterior to c setae. Gates (1974) calls these "vaginal apertures".

Genital markings: Large central raised pad centred in 17 between male pores and faintly repeated in 18; sometimes not developed or as elliptical, opaque area in 16-18 (Gates, 1982).

Septa: From 4/5; (6/)7/8/9 and 14/15 thickened.

Dorsal blood vessel: Single truncated before anterior hearts.

Hearts: Hearts 7-11 all distended with blood in some Qld specimens.

Gizzard: Weakly muscular in 5 immediately behind pharyngeal mass.

Calciferous glands: Ventral sets paired in 10 and 11 (concealed by seminal vesicle): large and pink due to blood supply with many internal lamellae; also in 12 (concealed by seminal vesicle) a pair of lobular, yellow calciferous glands which are medially placed lateral to the oesophagus and ducted posteriorly into it in 13. This latter pair supplies by largish blood vessels (from supra-oesophageal vessels).

Intestine origin (caeca, typhlosole): 14 or close to 14/15. Caeca and typhlosole absent. Note that small, supra-intestinal glands present in from eight to forty-two segments between 62-132 (Gates, 1972: 52, 1982: tab. 8) that may be at least partly related to an immune response in the worms.

Nephridia: Pair of large coiled nephridia obvious in each segment from 4.

Male organs: Testis not found, but large, unpaired sacs seen ventrally in 10 and 11; seminal vesicles occupy 11 and 12 and are filled with coagulum.

Ovaries: Large egg filled sacs attached to each spermathecal atrium by long coiled tubes in 14.

Prostates: Large pair of digitiform euprostates, with white muscular sheen from 18 extending to 23; acutely muscular enlargements of loop of paired sperm ducts which attach to apex of copulatory chamber mound internally. A smaller blind duct attaches to base of mound mesially.

Spermathecae: Atrium with muscular sheen in 14, extends back into long flaccid, convoluted gland, filled with coagulum and enclosed sheath; at junction oviduct attaches and is opposed by small glandular outgrowth.

Gut contents: Soil and/or organic matter - this species appears to be an adaptive feeder and will survive in unamended soil (as noted below) but also flourishes on organic material.

Cocoons: Dark coloured and a tapered lemon-shape (mean size approx. 6 x 3 mm from Reineke & Viljoen, 1988 who also provide incubation and hatching data); may contain from one to eight hatchlings (Gates, 1982).

Notes: Small saccular ‘brown bodies’ were observed loose in coelomic cavities from 7 posteriorly, these may enclose shed setal follicles (as noted by Gates, 1972). Gates’s (1982) specimens differed in that the anterior hearts were not distended with blood. The testis funnels of this species are small and free from spermatozoa which aggregate in the ducts, thus are easily missed.

Life Cycle: This genus is bi-parental characterised by internal fertilisation before production of cocoons. Initial studies were relatively recent, for example by Neuhauser *et al.* (1979) who found best growth on horse manure or activated sewage sludge. Life span can be 1-3 yrs, with *Eudrilus eugeniae* life cycle ranging from 50-70 days and sexual maturity reached at 35-50 days in culture (Vilijoen & Reineke, 1989). Reineke & Vilijoen (1988) reported that in cattle manure substrate at 25°C cocoons produced by adult worms between the ages of 70-100 days old were incubated for ca. 17 days before producing a mean of 2.7 hatchlings per cocoon (range 1-8) with 84% hatchling success. Dominguez *et al.* (2001) had similar findings with cocoons hatching in only 12 days at 25 °C that reached maturity in as little as 35 days (total 47 days). The latter findings concluded that mature worms produced 3.6 cocoons per week with 2.2 viable hatchlings per cocoon (= 6.5 hatchlings per worm per week on average). Viljoen & Reinecke (1989, 1994) reported first indication of clitellum at between 35-45 days; worms with fully developed clitellum copulated readily and formation of cocoons started within 24 hours after copulation and continued up to ±300 days. These rates of growth and production are amongst the highest currently know for any earthworm.

Parasites: Gates (1982: 74) says that protozoans had not been reported although nematodes were known.

Regeneration: Gates (1982: 74) reports possible 'head' regeneration as well as more easily observed 'tail' regeneration and sometimes abnormalities like forked tails.

Ecology and economics: See Blakemore (2015). Ecology of the three most common vermicompost species, *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavatus* that are most often bred in worm farms and fed on household vegetable wastes or animal manures are detailed by Kale & Bano (1991), Reinecke *et al.* (1992), Kale & Sunita (1993) and Dominguez *et al.* (2001). Comparative studies generally show *E. eugeniae* to be a most productive species in tropical zones or under cover in temperate regions where it is bred mainly for fish bait since its large size makes it particularly easy to handle and harvest. It is also used as a commercial meal high in protein and for fish, birds, etc. that reject the taste of *Eisenia fetida.* For example, specimens for the current study were purchased from a commercial worm farm in Brisbane, their stock had been established from surface-sterilized cocoons obtained from Canada (G. Bosanquet pers. comm.) and as well as bait it is the preferred food for duck-billed platypuses (Gates, 1982: 74) as also supplied to the Queensland National Parks and Wildlife Service in Brisbane for this purpose at their zoo (pers. obs.). In contrast, in the Philippines and India this worm is favoured most for producing vermicompost fertilizer for the organic farming market.

As in North America, the main commercial use in Australia is for breeding as fish bait where it is known colloquially as the '*African Nightcrawler*'. In the current studies, a propensity to escape from containers at night and wander adds justification to this common name. Despite its potential for mobility, there were no records of

natural colonization for North America (Gates, 1958, 1972, 1982) nor Australia, and such records from New Zealand are now known to be mistaken identities. As Gates (1958) said: "*This species, originating in tropical Africa and until very recently known only from the tropics, has been raised and distributed in the United States for several years by earthworm culturists. Sales appear to be mostly to anglers for bait. Escapes of live specimens into natural environments must have been numerous. As yet, however, there are no records to indicate acclimatization and permanent colonization in mainland states*." This was slightly counterindicated by his record from soil under oak tree at Vero Beach Laboratories, Florida (Gates, 1982: 72).
Nevertheless, its spread may require closer monitoring as it is a widely cultivated species in Brazil too and there are some records of its survival away from worm farms, mainly in areas of high organic matter, but also in gardens and some vegetable or fruit fields (Brown & Fragoso, 2007: 372). It was also collected from waterfalls and river sites on Guadeloupe (Ref.) but reports from mountainous forest areas in Negros Occidental, PI by Flores (2007) were not confirmed (Blakemore, 2015).
Preferring bedding material rich in organic matter when in culture, this savannah worm also survives in unamended soils (M'ba, 1978). It was successfully maintained for six months and reproduced in mesocosms of heat-sterilized but unamended clays (Vertisol and Krazonzem) and sandy (Podzol) soils in the glasshouse (Blakemore, 1994). Partasarathi (2007) also showed that over a year it will grow in clay loam but not as well as in composts where its biomass may be 6x as high. Thus it was considered highly adaptable to soil types.
Its environmental tolerance is broad as soil selections were investigated by Madge (1969) who introduced *Eudrilus eugeniae* and another tropical species to gradients of soil texture and found a marked preference for the 0.25 mm particle size fraction (fine sand) over both coarse and very fine sand. A series of choice trials conducted by Blakemore (1994) showed it had a tendency to select manure amended soil when given a choice compared to other species, and was found in clay soil rather than loam or sandy soil in 25% of all its observations. Habitat requirements were tested by Madge (1969) who introduced *Eudrilus eugeniae* and another tropical African species to a soil moisture gradient and found 65% of the earthworms in the 12%-17% moisture sectors after 48 hours. Tolerated pH range was between 5.6-9.2 and for temperatures, he found optima between 23°C and 31.5°C. In growth experiments, Viljoen & Reinecke (1992) reported that no *Eudrilus eugeniae* juveniles survived below 12°C or above 30°C and optimal temperature for growth and reproduction was around 25°C. Attempts to establish it in natural environments found that the worms do very well until the temperature drops to 40°F (4°C), at which time they die (Gates, 1972: 52). Sims & Gerard (1985; 1999) say that temperatures below 10°C are not tolerated and that the optimum breeding temperatures are 21-27°C. However, Domingues et al. (2001) found optimum moisture and temperatures for growth of near saturation at 80-82% and 25-30°C. These moisture and temperatures correspond well to findings reported by Blakemore (1994) except moisture preferences ranged 20-25% and preferred soil temperature was 25°C.
E. eugeniae is plentiful in coastal, shaded savannah grasslands of its West African homeland where copious surface casts are produced – remarkably, up to 140t ha^{-1} per annum are deposited according to Madge (1969). These casts are a very distinctive as numerous small pellets (pers. obs) - see description in **Worm Casts** section above.

In mesocosm soil cores, Blakemore (1994) reported that *Eudrilus eugeniae* produces distinctive pellet-like casts (2-3 x 1mm) on the surface of soil especially near container

edges where the worms burrowed and they had the highest surface cast production of a dozen species tested supporting the findings for a high casting rate of *Eudrilus eugeniae* estimated by Cook *et al.* (1980) of up to 2.43 g soil per g fresh weight worm per day. Blakemore (1994) observed that, where casts for this species were deposited on the surface, the plant roots sought them out and that casts fallen over the lip of the cores into the base tray also had root hairs firmly attached to the pellets at the base too; and when lifted looked like miniature bunches of grapes on a vine. This may be explained by *Eudrilus eugeniae* having significantly higher nutrients in its casts compared to the soil matrix especially nitrate-N, K and Zn which were twice that of the soil (Blakemore, 1994). The presence of this worm also had a positive influence on water infiltration rates to soil cores in the glasshouse in one case 20 times the rate of the control core.

A series of glasshouse experiments found significant yield increases when this worm was introduced to soil cores ranging from 21-74% for oats and 15-50% for grass, compared to uninoculated soil (Blakemore, 1994). As one of a dozen species later tesed in two field inoculation trials, *Eudrilus eugeniae* showed a significant pasture yield increased of 84-120% compared to controls, despite the result being considered inconclusive as no survivors were found after one year during a particularly severe drought (Blakemore, 1994; 1997).

Microbial aspects: Srithy *et al.* (2013) determined the predominant microorganisms found intestine of *Eudrilus eugeniae* in foregut, mid and hindgut were bacteria, actinomycetes and fungi respectively. These authors also note that the diversity of types and number of fungi, bacteria, actinomycetes, yeast and protozoa in the casts of *E. eugeniae* and other vermicomposting species fed on different substrates were reported by many researchers. It is perhaps from the microbially active medium that most benefits of worm casts accrue relating to mineralization and release of nutrients as well as plant-growth promoting enzymes and agents. Studies by Parthasarathi & Ranganathan (2000) showed enzymes (cellulase, amylase, invertase, protease and phosphatase) declined as casts aged. Parthasarathi (2006) found *Eudrilus eugeniae* fed on sugar cane pressmud with more than four fold increase (significant $p<0.05$) in microbial population (fungi + bacteria + actinomycetes) and dehydrogenase enzyme activity in fresh casts than in uningested pressmud that would lead to enhanced nutrient mineralization, but this activity gradually decreased in a month.

Effects of Vermicompost on Yield: Kale *et al.* (1992) briefly commented on some applications of *Eudrilus eugeniae* vermicompost on some crops, such as an experiment with application equivalent to 5t per ha plus 50% of the recommended chemical fertilizer that gave a significantly higher yield of rice in outdoor pots. A similar application of vermicompost in a corn field entirely replaced fertilizer use. The rice results were similar to those reported by Pontillas *et al.* (2009) from Philippines. However, the combination of vermicomposts with artificial fertilizers may actually have reduced efficacy since there is often a need to determine whether to adopt wholly organic or non-organic methods. Unpublished data from Kahariam organic farm, Philippines are that application rates of between 1.5-3 t per ha are adequate to produce rice yields above the local average without the need for chemical additions.

Radioactivity and biocide effects: Eno (1966) found *Eudrilus eugeniae* to be less susceptible to irradiation than *Lumbricus terrestris* in the range 16-64 kR. In Nigerian soils, this worm had much higher concentrations of DDT and its products compared to the surrounding soil and its production of surfaces casts virtually ceased in DDT treated plots that was considered a contribution of overall decline in fertility of these plots (Cook *et al*., 1980). Concentration of heavy metals (Cu, Zn, Pb, Cd and Hg) in the tissue of *E. eugeniae* fed on municipal wastes accumulated beyond levels acceptable for protein meal production (Graff, 1982), but this can be used for soil bio-remediation .

Pharmaceutical uses: The antimicrobial, antioxidant, anti-inflammatory and anticoagulant properties of *Eudrilus eugeniae* have been variously studied (Mathur, 2010). When *Eudrilus eugeniae* was dried and powdered, it produced antimicrobial responses when assayed against seven human pathogens of between 45-90% inhibition on agar plates (Anjana *et al.*, 2013). Extracts from this worm showed antibacterial and antifungal properties that varied depending on the formulation (Mathur *et al.*, 2010).

Recently, earthworm extracts including from *E. eugeniae* have been found to have anti-wrinkling properties as potential new "anti-aging" agents (Azmi *et al.*, 2014).

Summary of Importance: *Eudrilus eugeniae* is a versatile vermicomposting species of the tropics or indoors in temperate regions useful for:- recycling soil organic matter (i.e., maintaining humus), enhancing carbon sequestration, soil bio-remediation, providing stock feed protein, bioprospecting for pharmaceuticals/cosmetics or perhaps silk production from the Y-shaped glands (as reported by Eisen, 1900: 141) and, trivially, as fish bait. Its geographical range and applications of its products are rapidly expanding with a summary of its vermiculture potential provided by Li *et al.* (2010). The field identification method noted in relation to the male pores protruding under finger pressure and the mtDNA barcode data (Appendix) should allow rapid identification of this economically and ecologically important species and confirm its separation from similar *Eudrilus pallidus* (Michaelsen, 1892: 216) from Accra, Ghana [?syns. *E. buettneri* Michaelsen, 1892: 256; *Eudrilus ifensis* Segun, 1978, but see Sims (1965: 304)] plus its sub-species *E. pallidus atakpamensis* Michaelsen, 1913: 40 and *E. simplex* Michaelsen, 1913: 37 from Togo.

[**Note:** Ethics of releasing an exotic species into the Australian bush was agreed to by PhD supervisors and staff at CSIRO Qld (noted in Blakemore, 1994) on the grounds that this species was present in Australia, having been imported from Canada by a wormgrower some years previously; moreover, it was already sold for fishing bait in the town near to the release site (Mundubbera) – pers. obs. The species is sexual (i.e., requires a partner to reproduce) and this area, classed as dry, arid sub-tropical, was several Km from a water course. Thus the likelihood that it would persist due to the single release event was considered negligible. However, in these more informed times, I personally would not contemplate such a release in the future. Commercial solution for the worm bait/compost market in Australia could be found from the pool of 2,000 or so native Australian species, some of which are already bred as bait (Blakemore, 1997, 2000, 2002, 2008, 2012) but, again, redistribution of these natives is also ill-advised].

Appendix: mtDNA COI barcode data (BLAST from http://blast.ncbi.nlm.nih.gov)

>Ee = *Eudrilus eugeniae* from Kahariam farm, Batangas 11th Nov., 2013. Coll. RJB.

DNA data received by lab. 24th Dec., 2013 (i.e., more than one month after sampling). Nil result due to transportation delay and mishandling of tissue samples by UPV.
Resamples:
>P14 *Eu. eugeniae* from Kahariam, Philippines 21st Nov., 2013 in 70% ISO-Ethanol. Coll. RJ Blakemore/Rowena Ocenar.
Sequence (584bp):
TAAGACAGCCGGGTGCTTTTCTAGGAAGAGACCAACTCTATAACACTATCGTTACAGCTCAT
GCTTTTCTAATAATCTTTTTCCTTGTAATGCCAGTTTTTATTGGCGGATTTGGAAATTGATTAC
TCCCACTAATACTGGGAGCGCCCGACATAGCATTCCCCCGACTAAATAATTTAAGATTTTGAT
TATTACCTCCTTCACTAATTCTCTTAGTTTCGTCAGCTGCAGTTGAAAAGGGTGCAGGTACA
GGATGAACTGTTTACCCACCACTTGCAAGAAATCTTGCTCATGCGGGGCCCTCAGTAGACCT
AGCCATTTTCTCTCTTCATCTTGCAGGGGCATCATCTATTTTAGGGGCAATTAACTTTATTACA
ACAGTAATTAATATACGATGATCCGGTCTTCGATTAGAACGAATTCCACTATTTGTATGAGCA
GTAGTAATCACTGTAGTGCTACTTCTTCTATCACTTCCAGTCTTAGCGGGGGCAATCACAATA
CTTCTCACAGATCGTAATCTCAATACTTCATTCTTCGACCCAGCTGGGGGTGGAGATCCAAT
TCTTTATCAACATTTATTC
megaBLAST result: *Eudrilus eugeniae* (KC122194.1) from India, Id. 584/584 (100%), i.e., perfect match; *Eudrilus eugeniae* (HM219171.2) from Thailand, Id. 564/584 (97%), i.e., some difference. GenBank: HM219171.2 origin in Thailand not stated in publication by Loongyai *et al.* (2011).

>P15 *Eudrilus eugeniae* from Kahariam, Philippines 21st Nov., 2013 in 70% Ethyl-alcohol. RJB/RO.
BLASTn result: P14 vs. P15 Id. 584/584 (100%), i.e., perfect match so preservation methods with different alcohol OK, cf. time delay for first samples that failed.

Eudrilus eugeniae was said to have been introduced from West Germany to both India (in the late 1970s according to Meenatchi *et al.*, 2009) and to Philippines (in the early 1980s) thus supporting the same species origins. However, both these statements need to be tempered since Stephenson (1923: 486) already recorded it in India from 1898, and other stocks of *Eudrilus eugeniae* were said imported to Philippines from Australia. However, it was a Mr. Rossi who introduced African Night Crawlers (*Eudrilus euginae*) during the early 1980s with the advocacy of organic farming at Negros Island such as La Carlota, Sagay, and Dumaguete cities of Negros Oriental, Philippines. Other groups from Manila, Philippines used another species introduced from Germany (Ref. 2014).

Sharma *et al.* (2011b) investigated DNA markers in *Eudrilus eugeniae* finding two strains, and Meenatchi's study identified six distinct molecular strains in their Indian samples with highest and lowest genetic similarity index values of 1.0 to 0.40, but neither of these studies tested the COI gene. Cf. GenBank: KC122194.1 from India by Gupta *et al.* "*Earthworm for production of compost from coconut leaf biomass*" (unpublished?), submitted in November, 2012.

Genus ***Hyperiodrilus*** Beddard, 1890

Hyperiodrilus Beddard, 1890: 563; Michaelsen, 1900: 408; Sims, 1985: 11.

Note: Synonym *Heliodrilus* Beddard, 1890: 625/7 (type *He. lagosensis* Beddard), itself with synonym *Iridodrilus* Beddard, 1897: 346 (type *Ir. roseus* Beddard) from Michaelsen, 1900: 408, combined by Sims (1985: 13) it was restored by Owa (1994)

although *Alvania* Beddard, 1893: 271 (type *Av. millsoni* Beddard) was not reallocated and may yet be synonymous. A dozen African species are currently known (ref1, ref2).

Type-species: *Hyperiodrilus africanus* Beddard, 1890: 236, first described from soil imported into Kew Gardens from Lagos, Nigeria type-locality (under ICZN, 1999: Art. 76.1.1).

Distribution: So widespread in equatorial West and Cenral Africa - from Nigeria, Ghana and Ivory Coast to Chiloango River in "*Portugese Congo*" - that Michaelsen (1910c: 125) classed it as a peregrine. Reports of *Hy. africanus* from Brazil are by Righi (1972) and Sutter *et al.* (2006) (cf. G. Brown pers. comm. 2006). It is diagnosed below.

Diagnosis: It is a 12-16 cm long worm with gizzards in 18-23 that lives in the upper 10-20 cm and produces large tower-like casts from 2.5 to 8.0 cm high, and 1.0 to 2.0 cm in diameter (Madge, 1969). It is stated to be an r-strategist (Ref.1, Ref.2) suggesting a high ability to recover populations affected by drought. For fuller description see Beddard (1891: 236 plus numerous figures); Michaelsen, 1891; 1900: 410; Zicsi & Csuzdi 1986: 405; Sims, 1985: 13; Sims 1987: 384, Csuzdi & Tondoh, 2007; etc. and also *Hy. africanus* f. *vogelii* Omodeo (1955a: 215) - **syn. nov.**].

Notes: Other worms described by Beddard (1891, 1897) from Lagos material delivered to Kew were *Heliodrilus lagosensis* and *Iridodrilus roseus* (?= *Heliodrilus roseus*) - see Michaelsen (1900); Sims (1985); Owa (1994); Sims & Gerard (1985; 1999). A congeneric species, *Hyperiodrilus euryaulos* Clausen, 1914 is vermicultured for aquaculture food in Africa (Ref.).

A Natural Break..

Taxonomic sections above encompass Moniligastridae as part of the Megadrili, then move to the ancient precursors similar to the Ocnerodrilidae and progressively through their decendent, the remainder of the Superfamily Megascolecina: Acanthodrilidae --> Octochaetidae --> Exxidae --> Megascolecidae, the latter containing both 'primitive' (e.g. lumbricine, holoic, tubular prostates) and 'derived' (non-lumbricine, non-holoic, non-tubular) genera (see Blakemore's 2013 review).

Next Glossoscolecidae and Eudrilidae form separate but closely related groups, with the latter the most advanced reproductively, having direct fertilization rather than storing sperm in spermathecae/spermatophores as with most other megadriles.

The Taxonomic sections following refer to mostly aquatic groups of **Almidae, Criodrilidae, Sparganophilidae and Lumbricidae** that often share simplified, convergent or atrophied characteristics relating to their often aquatic modes of life. The probable precursors to the relatively 'advanced' yet widespread and 'ancient' Lumbricidae may be found in these more 'primitive' groups. However, Lumbricidae is not a particularly representative example of an 'earthworm' in the context of World families as it is not an exceptionally diverse nor anaotmically varied; it is just the most studied due to its prevelence in the northern science states. This has tended to allow an overemphasis to the exclusion of all others whereby the term 'Lumbricidae' is quite incorrectly, as I hope this publication will show, used synonymously with 'Earthworm' and not infrequently from the higher academic levels where a more informed and balanced view would be expected.

Yamaguchi (1958: 328, tabs. 3-5, fig. 25) from Hokkaido provides a good overview/ summary of Megadrili phylogeny based on ideas of Michaelson/Stephenson.

These broad divisions thus give an indication of megadrile descent as they are mostly arranged 'progressively' in approximate assumption of acquisition of non-primitive characters from the more 'primitive' to give both chronological and phylogenetical order. Naturally the inferred changes have occurred in parallel rather than in series as presented and actual overview is of a perpendicular scan across the leading edge of developments. Thus some so-called 'primitive' groups 'happily' adapted to their (mostly stable?) environment persevere through the longest times.

Within these progressing groups however, genera and spp are arranged alphabetically for 'convenience' of reference without implied phylogenic merit.

Family **Almidae** Duboscq, 1902

Glossoscolecidae (parts – Microchaetinae, Criodrilinae): Michaelsen, 1900: 420.

Alminae (Glossoscolecidae) Duboscq, 1902: xcvii-cvi; Michaelsen, 1915: 276.

Microchaetinae (Glossoscolecidae) (part.): Michaelsen, 1913; Stephenson, 1930: 899.

Microchaetidae (part.): Gates, 1972: 233 [included Almidae - but not supported here].

Almidae: Sims, 1980: 111; Sims & Gerard, 1999: 42; Omodeo, 2000: 186 (excluding his mispelt "Glyphydrilidae").

Type-species and type-genus: *Alma nilotica* Grube, 1855 (syns. *Siphonogaster* + *Digitibranchus* Levinson, 1889/1890: 319-321 with types *S. aegyptiacus* + *D. niloticus*) .

Diagnosis (modified from Michaelsen, 1900; Gates, 1958; 1972; Sims, 1980): Prostomium (always?) zygolobic. Freshwater worms often in riverside muds. Setae lumbricine. Dorsal pores absent. Clitellum annular and often extensive (behind the male pores). Female pores on 14 (or 13 and 14 in *Glyphidrilus kuekenthali* Michaelsen, 1896). Male pores inconspicuous between 15-30, not postclitellar, near tips or middle of long claspers in *Alma*. Tubercula pubertatis ridge-like (*Callidrilus*), aliform (*Glyphidrilus* and *Glyphidrilocrius*), or absent (*Alma* and *Drilocrius*). Spermathecae (always behind testis segments?), multiple, adiverticulate, or absent. Prostates with ducts usually absent but 'prostatic-like' glands (racemose with tubular duct) present in *Callidrilus* leading to male pores in or near 17/18. Gizzards absent, or present as oesophageal dilations in 5-9 (or behind ovarian segment); extramural calciferous glands, and caeca absent. Nephridia holoic. Ovaries (fan-shaped?) in 13. Ova not yolky. Lateral lines absent (as usual). Glyphidrile 'wings' (a longitudinal lamellar ridge on each side in mature specimens, called ala or alae, plural) sometimes present. Testes holandric, paired in segments 10 and 11 or (*Areco*) metandric in 11 only.

Distribution: Aquatic or limnic or in caves in tropical America, tropical east Africa, Egypt (e.g. Ghabbour, 2009), peninsular India, Sri Lanka, and southeast Asia to Sulawesi. Seven genera including monotypic *Areco* Righi, Ayres & Bittencourt, 1978 for *Areco reco* from Brazilian Amazonia and *Progizzardus* for *Progizzardus varadiamensis* Nair, 2010 from the Varadiam in Kerala at the Western Ghats of India. *Callidrilus* type, *C. scrobifera* Michelsen, 1890: 20, is described from Mosambique and other species are in Uganda. West African *Alma millsoni* (Beddard, 1891: 48) was first recorded from Kew Gardens, London (Beddard, 1891; 1893) as *Siphonogaster millsoni*.

Remarks: In contrast to Eudrilidae (above), Almidae is a relatively 'primitive' family (but there is the question of convergence in aquatic species due to their habitat). All

genera tend to be rather poorly known and are perhaps closest to *Criodrilus* that, however, has spermathecae replaced by spermatophores. Michaelsen (1900) had *Alma* in Criodrilinae, and Almidae was combined with Lutodrilidae in a Superfamily Almoidea by Reynolds & Cook (1993: 4), whereas Omodeo (2000: 186) had *Alma* in its own family separately from the residue in "Glyphidrilidae" based on the 'claspers' found only in *Alma*.

Peregrine species occur from genera *Glyphidrilus* – that is placed by some authors in Glossoscolecidae and/or Microchaet-inae/-idea – and possibly *Drilocrius* that has its type, *D. iheringi* (Michaelsen, 1895), in Sao Paulo, Brazil and Paraquay according to Michaelsen (1900: 469). One other species, *D. buergeri* (Michaelsen, 1900) (sometimes misspelled *"burgeri"*) from Bogota, Colombia is listed from Argentina by Mischis (2004: 268) and Blakemore (2007); see also Gates (1958).

Aquatic *Glyphidrilus* Horst, 1889 has disjunct distribution in Tanzania, South India and SE Asia that was difficult for Gates (1972: 234-236) to interpret as being due to overland transportation via India and Sri Lanka. However, distribution may be attributed to sea transportation from Asia, possibly via south India, when it is realized that Madagascar and possibly the East coast of Africa (where *G. stuhlmanni* Michaelsen, 1897 occurs) were colonized by seafaring peoples from Borneo (whence *G. kuekenthali* Michaelsen, 1896 was described), and that these or successive peoples may have transported soil with root-stocks, or water for drinking and watering plants on the voyages (Blakemore, 2007). [Or, as Gates (1972: 236) asks, perhaps some African spp were refered to the wrong genus? – cf. those yet removed to *Callidrilus* Michaelsen, 1890]. Discovery of exotic *Glyphidrilus* in Madagascar is therefore soon to be expected.

Genus **Alma** Grube, 1855 (type *Alma nilotica* Grube, 1855, syns. *Siphonogaster aegyptiacus* Levinsen, 1889: 319; *Digitibranchus niloticus* Levinsen, 1889: 321).

A brief description of *A. millsoni* follows as this is first described from Kew after delivery from Lagos, Nigeria (type-locality); a recent report claims it can be cultured.

Alma millsoni (Beddard, 1891)

[Fig. 1 and Fig. 2 of *Alma millsoni* from Beddard, 1891; Fig. of *Alma millsoni* 'wings' from Beddard, 1896: fig. 198].

Siphonogaster millsoni Beddard, 1891: 48, figs. 1-3; 1893: 264, tab. 26, figs. 17-22; 1895: 685, tab. 4, fig. 5; 1896: 387, fig. 198.

Alma millsoni: Michaelsen, 1895: 12; 1900: 467; [Non Michaelsen, 1913: 59, 82 (= *A. togoensis*)]; Michaelsen, 1915: 289; Csuzdi, 2009 (syn. *schultzei*).

Alma schultzei Michaelsen, 1915: 280. From Cameroon. Type in Hamburg.

Diagnosis: Colour is black in the anterior, brown further back and with a green tail. Body square in section behind male pores. Clitellum faint, possibly between 33-63 or further posteriorly. Size, ca. 130 mm by 3-4 mm. Setae lumbricine, paired. Femal pores on 14. Penes on 18 on long alae that have rows of penial setae. Gizzard absent. Nephridia avesiculate holoic, absent before 15. Hearts in 8-12. Testes paired in 10 and 11. Seminal vesicles in 9-12. Spermathecae absent.

Distribution: Originally from Kew in material sent from Lagos; it is not known if the specimens were obtained live from Kew or not. In Lagos, Nigeria in waterlogged sites it is known as the "*Yoruba worm*".

Notes: A subspecies is *Alma millsoni zebangui* Deboscq, 1902: 2 according to Csuzdi's website, as redescribed by Michaelsen (1915). The ecology of this species was said by Beddard to be reported in the 'Kew Bulletin' by a Mr Alvan Millson of Lagos. Dedeke *et al.* (2009) report its cultivation in brewery waste (brewers dried grain) in moist coconut husk bedding.

Genus **Drilocrius** Michaelsen, 1917 (type *Criodrilus iheringi* Michaelsen, 1895) was sometimes included in the Glossoscolecidae (e.g. Reynolds & Cook, 1976: 51). It has closely-paired lumbricine setae; male pores on 15 or 16 on a flat area between cushion-, club- or wing-shaped copulatory organs or paddle-shaped claspers in *D. alfari* (Cognetti, 1904) from San José, Costa Rica; spermathecae anteriorly; gizzard in 5 or 6 or absent but lacking calciferous glands; holoic nephridia; holandric, lacking testis sacs, copulatory sacs and prostates. It was separated from *Criodrilus* by Michaelsen (1918) on the ground of the presence of spermathecae, and it differs from *Kynotus* by its lack of prostates. Seven species are known from tropical South and Central America.

Genus **Kynotus** Michaelsen 1891 (type *Geophagus darwinii* Keller, 1887, syn *K. madagascariensis* Michaelsen, 1891) is perhaps related and was included in the Microchaet-inae/-idae (e.g. Michaelsen, 1900: 454; Benham, 1892; Stephenson, 1930: 900; Reynolds & Cook, 1976: 54) or given separate monotypic family status. It has lumbricine setae; male pores on 15 or 16 within muscular copulatory pouches having a tubular organ attached internally; spermathecae anteriorly; gizzard in 5; holoic nephridia;

holandry, and genital setae, but lacks calciferous glands. Michaelsen (1913) thought *Kynotus* was similar to *Microchaetus* (that he thought derived from *Glyphidrilus*) but *Kynotus* was derived from aquatic *Callidrilus*. Twelve terrestrial species in Madagascar.

Genus **Glyphidrilus** Horst, 1889

Glyphidrilus Horst, 1889: LXXVI; Stephenson, 1921: 767; 1923: 490; Michaelsen, 1900: 459 [syns. *Bilimba* (type *B. papillata*); *Annadrilus* (type *A. quadrangulus*)].

Type-species: *Glyphidrilus weberi* Horst, 1889.

Diagnosis: Lumbricine. Male pore in clitellar region which is characteristically marked with 'claspers' or wings. Often spermathecate. Gizzard in 8 or 7-8. Holoic. Aquatic.

Distribution: East Africa, India (but not Nepal!?) and Southeast Asia (Blakemore, 2007), e.g. Malaysia (Michaelsen, 1903) as noted above and below. Recently, new records and two new species were described by Shen & Yeo (2005) from Singapore and Malaysia: i.e., *Glyphidrilus gatesi* from a swamp at Johore, Malaysia; *G. singaporensis* from Bukit Timah, Singapore; plus they found *G. horsti* Stephenson, 1930 from Pulau Berhala in Singapore and two unidentified species. A recent report is beside R. Mekong, Thailand. About 20 species are currently known, plus some synonyms, as checklisted below...

Gates (1972) thought external genital characters of glyphidrilids were highly variable individually whereas internal characteristics tended to be uniform. Nevertheless position of these external features are still often used for initial species determination.

Checklist of *Glyphidrilus* species (original)

1. *Glyphidrilus annandalei* Michaelsen, 1910: 101 [syns. *G. achencoili* (laps.) Cognetti 1911: 506; *G. fluviatilis, elegans, rarus, saffronensis* all by Rao, 1922: 53, 62, 64, 66 as per Stephenson, Stephenson (1923: 491)].
2. *Glyphidrilus birmanicus* Gates, 1955: 61 [Myanmar].
3. **Glyphidrilus buettikoferi* Michaelsen, 1922: 9 [corr. of G. büttikoferi].
4. *Glyphidrilus ceylonensis* Gates, 1945: 89 [from Palmadulla, Sri Lanka at 3-5,000m AMSL also reported from Vietnam; mispelt "*G. ceylonicus*" on amateur website - *insects.tamu.edu/research/collection/.../Almidae.txt*].
5. *Glyphidrilus mekongensis* Panha & Chanabun, 2012 [Thailand].
6. *Glyphidrilus gangeticus* Gates, 1955: 55 [India –excellent description here Ref.].
7. *Glyphidrilus gatesi* Shen & Yeo, 2005: 16 [originally *Glyphidrilus* sp. Gates, 1938: 221 from Sungei Kayu Swamp, Johore, Malaysia].

8. *Glyphidrilus horsti* Stephenson, 1930: 4 [sometimes mispelt "hosti" from Pulau Berhala, Straits of Malacca and from Singapore].
9. *Glyphidrilus jacobsoni* Michaelsen, 1922: 10.
10. **Glyphidrilus kuekenthali* Michaelsen, 1896: 195 [also as *kükenthali*, or mispelt "kukenthali"; from Baram River, Myanmar].
11. *Glyphidrilus malayanus* Michaelsen, 1903: 35 [from Malay Peninsula].
12. *Glyphidrilus papillata* (Rosa, 1890: 386) [syn. *Bilimba papillata* Rosa, 1890].
13. *Glyphidrilus quadrangulus* (Horst, 1893: 44) [syn. *Annadrilus quadrangulus* Horst, 1893 mispelt as "*G. quadrangula*" by Michaelsen, 1896:195; Sumatra].
14. *Glyphidrilus singaporensis* Shen & Yeo, 2005: 18 [Singapore].
15. *Glyphidrilus stuhlmanni morogoronensis* Zicsi, 1996: 21 [E. Africa].
16. *Glyphidrilus stuhlmanni stuhlmanni* Michaelsen, 1897: 62. [Sometimes misreported "1898". From East Africa, see Michaelsen (1900: 461)].
17. *Glyphidrilus spelaeotes* Stephenson, 1924: 133 [from Assam, India].
18. *Glyphidrilus tuberosus* Stephenson, 1916: 349 .
19. *Glyphidrilus weberi* Horst, 1889: 76 [Sumatra, Java, Celebes, Flores, etc.].
20. *Glyphidrilus yunnanensis* Chen & Xu, 1977: (178?) 181 [Yunnan, China].

***Taxonomic Notes:** *G. kuekenthali* is often misspelt "*Glyphidrilus* kukenthali" eg. in Wikipedia fig, but originally spelt by Michaelsen (1896: 195) as G. *kuekenthali* (cf. his figure legend); albeit Michaelsen (1900: 460) later 'corrected' this to "*kükenthali*". Herein orginal spelling is restored, under ICZN (1999: Arts. 32.3 and 32.5.2.1). Similarly, *G. buettikofei* Michaelsen, 1822 must have German umlaut corrected to "ue" as here (and as formalized by Blakemore, 2010) and again herein.

[Note: Ugandan *Callidrilus ugandaensis* (Jamson, 1968: 387) was originally misidentified as *Glyphidrilus ugandaensis*]! Some new Thai species recently found.

Key to widely distributed *Glyphidrilus* species

1. Dorsal blood vessel complete in front of hearts ..... *G. ceylonensis* Gates, 1945 from Sri Lanka and reported from Vietnam, Laos and Cambodia (Thai & Samphon, 1989; Thai & Do, 1989; Thai, 2000).

   Dorsal blood vessel (always?) aborted in front of hearts of 7-9 2

2. Papillae absent or midventral (and/or in a single series on each side) …….. 4

   Paired or unilateral papillae with none mid-ventrally ……... 3

3. Papillae two or three in series on each side …… *G. tuberosus* Stephenson, 1916: 349 from Orissa & Bengal, NE coastal India; Bangladesh, and Kamra (District Attock) Pakistan.

Paired in 18-21 and 32-24 …… *G. yunnanensis* Chen & Xu, 1977 – see below.

4. 'Wings' begin in 17-19 and end around segment 23-27 …. *G. papillatus* (Rosa, 1890) – see diagnosis and distribution below.

'Wings' begin after 20 …… 5

5. 'Wings' from 22,23 to around 32 ……..…….. *G. weberi* Horst, 1889 widespread from Sumatra, Java, Celebes, Flores.

'Wings' from 25-28 end behind segment 32,33 …. *G. annandalei* Michaelsen 1910 [syns. *fluviatilis, elegans, rarus* and *saffronensis* all by Rao (1922)], known from the Malabar coast to the Western Ghats of Tamil Nadu, India (Gobi & Vijayalakshmi, 2004), its biology is reported by Sobhana & Nair (2007).

A widely distributed species, *Glyphidrilus papillatus* (Rosa, 1890), is diagnosed here as an example of the group, and it is briefly compared to *G. yunnanensis* Chen & Hsü, 1977: 178 further below. Description of other taxa, e.g. *G. tuberosus* Stephenson, 1916; 1923 or *G. gangeticus* Gates, 1958, may be found from original authors' publication links.

Glyphidrilus papillatus (Rosa, 1890)

Bilimba papillata Rosa, 1890: 386, tab. 12, fig. 1. [Type locality Cobapo, Myanmar. Type, aclitellate and poorly preserved in Genoa Museum, 44025].

Glyphidrilus papillatus : Michaelsen, 1896: 195; 1900: 459; Stephenson, 1923: 493; Chen, 1938: 426; Blakemore, 2007; Blakemore, 2010: 540.

Diagnosis: Flesh coloured. Prolobous. Size 74-120 mm long by 3-6 mm wide with 130-330 segments. Genital pores all minute, superficial and difficult to detect. Wings from around 18 to 23,24-27 between setal lines b-c. Genital markings median, numerous in most of 9-21,23-33; and paired lateral in some of 12,13-30. Polythecal spermathecal pores at 13/14-16/17. Clitellum 13,14-40. Gizzard in 8. Intestinal origin 15. Last hearts in 11. Holoic with seminal vesicles in 9-12. Spermathecae absent, despite spermathecal pores! (spermathophores?, parthenogenetic?).

Habitats: Mostly in semi-limnic if not amphibious locations, e.g. paddy fields, buffalo wallows, wet organic soils.

Distribution: Widespread in Myanmar (Gates, 1972) and North Lampung, Sumatra,

Indonesia under secondary forest and agricultural land in both dry and rainy seasons (Hairiah *et al*., 2001: 20; van Noordwijk *et al*., 2004); also reported from Vietnam (along with *G. ceylonensis*) (e.g. Ref1, Ref2). Reports from Lucknow India were thought by Gates (1972: 237) almost certainly for *G. gangeticus* Gates, 1958, and a single Hainan report (Chen, 1938) may also be incorrect, although yet checklisted by Huang *et al.* (2006) who also report endemic *Glyphidrilus yunnanensis* Chen & Hsü, 1977. On the basis of this the latter, possibly widespread riverine species, is briefly described next:

Glyphidrilus yunnanensis Chen & Hsü, 1977: 178 (181?).

Diagnosis: L.123mm., D.6mm.(cl.), segs.139. Unpigmented, slight red on the clitellum. Clitellum saddle-shaped, 18-38 (=21). 'Wings' ventro-lateral, 22-32,33. Papillae large, round, paired or unsymmetrical,and situated between b and c. No median papillae. Setae paired, in 12:aa=2ab=bc=2cd=5/6 dd; in 50:aa=2ab=bc=2cd=2/3 dd. Nephridiopores in front of setae b. No obvious male pores, female pores nor spermatheeal pores. Gizzard in 8,undeveloped. Intestine begins in 16. Meroic. Last heart in 11. Seminal vesicle pairs or large funnels free in 10 and 11. Four pairs of large irregular seminal vesicles in 9-12. Ovisacs in 14. Testes,prostates and spermathecae undetected.

Distribution: "Menglun, Loso River, Yunnan" [=Luosuo River, a tributary of Lancang Jiang (Mekong River) along which a similar, and possibly synonymous, species was recently found in Thailand: *G. mekongensis* Panha & Chanabun, 2011].

Family **Criodrilidae** Vejdovsky, 1884

Criodrilidae Vejdovsky, 1884: 63; Michaelsen, 1921; Gates, 1972: 49; Sims, 1980: 107; Omodeo, 2000: 186 (part.); Blakemore, 2000: 33, 2002: 243, 2006: 398; Blakemore, 2007 [syn. Biwadrilidae Brinkhurst & Jamieson, 1971: 809].

Criodrilinae: Michaelsen, 1900: 463; Stephenson, 1930: 721.

Type-genus and type-species: *Criodrilus lacuum* Hoffmeister, 1845 [syns. *Criadilus* Udekem, 1855 laps.; *Hydrilus* Qiu & Bouché, 1998 (**syn. nov**. Omodeo & Rota, 2004: 222); *Guarani* Rodríguez & Lima in Lima & Rodriguez, 2007 (**syns. nov**. Blakemore, 2007)].

Taxonomic remarks: The *Hydrilus* taxon may merit provisional retention as species *Criodrilus ghaniae* (Qiu & Bouché, 1998) comb. nov. (Blakemore, 2007) on such characters as its dorsal pores (?and tubercula pubertatis), but determination of presence or absence of nephridia from the anterior apparently needs further investigation. South American species included in *Criodrilus* by Michaelsen (1900) – e.g., *C. breymanni* Michaelsen, 1897, *C. buergeri* Michaelsen, 1900, *C. iheringi* Michaelsen, 1895 – were transferred to *Drilocrius* Michaelsen, 1917 (Family Almidae) by Michaelsen (1918) as they possessed spermathecae rather than spermatophores (see Gates, 1958 and *vide infra*). The English species from Suffolk *Anagaster fontinalis* Friend, 1921, now in synonymy of *Helodrilus oculatus*, was erroneously associated with *Criodrilus* in the past and may account for the only British report. Trans-Aegean *Criodrilus dubiosus* Örley, 1881 was transferred as *Allolobophora dubiosa* by Örley (1885: 24) and now resides in *Aporrectodea* (Lumbricidae) or newly in *Eophila*; it is listed as "*endangered*" in Russian Red Book (1997). A new inclusion in *Criodrilus lacuum*, at both species and genus level, is Brazilian *Guarani camaqua* Rodríguez & Lima,2007 syn. nov. from Blakemore (2007) for reasons discussed below.

An amateur website has "*Criodrilus officeri Michaelsen, 1895*" which may be a mistake for *Cryptodrilus officeri* Spencer, 1895, or some other type of mistake.

Note: *Cirodrilus* Righi, 1975 (e.g. for *Ci. angaloi, Ci. righii*) is an unrelated genus belonging to South American Glossoscolecidae.

Family Diagnosis (from Michaelsen, 1900; Stephenson, 1930; Gates, 1972; Sims, 1980; Blakemore, 2006, 2007): Fresh and brackish water worms. Body quadrangular in section (at least in posterior). Prostomium zyboloic (epilobic in *Hydrilus*). Setae lumbricine. Dorsal pores lacking (present from 11/12 in *Hydrilus*). Nephropores in b lines (throughout?). Clitellum multilayered, annular in (14,15),16-45 or perhaps less

extensive (cf. *Hydrilus*). Tubercula pubertatis absent (cf. *Hydrilus*). Female pores paired on 14. Male pores on 13 (ex *Biwadrilus*) or 15 (*Criodrilus*) associated with internal bursae or 'prostatic glands'. Spermathecae absent but spermatophores, horn-shaped, tubular, or saccular, attached near male pores. Oesophageal and intestinal gizzards, calciferous glands, and caeca absent (but possibly some thickening of oesophagus in 5-7 and intestine in 15-20,21). Intestinal origin around 15-20. Typhlosole poorly developed or atyphlosolate. Hearts in (6),7-11. Nephridia holoic (avesiculate?); absent from anterior segments. Ovaries fan-, pear- or paddle-shaped in 13 (but not terminating in a single egg-string). Ova microlecithal (i.e., not yolky). Cerebral ganglia between segments 1 and 2 (cf. Sims, 1980: 114). Lateral lines absent!

Distribution and diversity: Holarctic including Palaearctic: Europe from Mediterranean to Moldavia [e.g. Italy; Hungary (Budapest), Austria (Linz); Germany (Berlin); France; Spain, Portugal, Yugoslavia, Greece [as reported by Michalis, K. (1993; 2003): "*Criodrilus lacuum* (Oligochaeta: Criodrilidae) earthworm species new to Greece" – ref], Turkey, Asia-minor, the Maghreb (Tunisia and Algeria) and the Levant (Syria, Lebanon, Israel, Palestine), and from Latvia, Poland, Russia to Amur River region of Siberia on the Pacific coast; plus Japan. Reports are of introduction of *Criodrilus lacuum* to America [plant pots in Baltimore (Gates, 1972) and from rice paddies in Rio Grande do Sul, Brazil (Knäpper & Porto, 1979; Lima and Rodriguez, 2007 for *Guarani*) and, doubtfully, to UK (cf. *Anagaster fontinalis* above). The immature specimens from southern India that Stephenson identified with *Criodrilus lacuum* probably were glyphidriles according to Gates (1972: 50), but Julka (1988: 39) yet claims it from India. Omodeo (1984), Timm (1999) and Martin (2004) provide some additional distribution data for some Criodrilidae species.

A definition of "Criodrilidae" by Omodeo (2000: 186) was too wide as it included these genera: *Criodrilus, Sparganophilus, Komarekiona, Lutodrilus,* and ?*Biwadrilus*; whereas *Komarekiona*, *Lutodrilus* and *Sparganophilus* are usually accomodated in Ailoscolecidae, Lutodrilidae and Sparganophilidae, respectively (see Blakemore, 2000; 2006). Cf. Omodeo (2000) concept of Glyphidrilidae vs. Almidae.

Remarks on the family: Sims & Gerard (1985: 41) suggest the present Palaeactic distribution is relictual of a wider, possibly pre-Pangean range dating to late Palaeozoic times but, despite the return of family Biwadrilidae, monotypic for *Criodrilus bathybates* Stephenson, 1917 [sometimes misspelt "*bathybathes*" or "*batybates*"], the Holarctic range is extended only slightly to again include Japan. The diagnosis of Biwadrilidae

by Easton (1981: 39) was within Criodrilidae ambit, indeed Sims (1980: 115; 1982: 285) suggested that the family be recombined with Criodrilidae as it differs only in details of its vascular system – in particular the presence of a supra-oesophageal vessel and possible lack of a sub-neural vessel, although both these characters are poorly defined in *Criodrilus* (cf. Lima & Rodriguez, 2007), and, further, on the presence of male pores and "*prostate glands*" in 13 rather than 15. Regarding supposed presence or absence of "*paired lateral lines*" (as found in a fish) – these were never satisfactorily demonstrated in *Biwadrilus*, despite claims by Nagase & Nomura (1937: 368) as repeated by Sims (1980: 106, 115). The only possible 'lateral lines' are due to blood vessels clearly visible through the body wall in the anterior segments in live specimens (pers. obs. and Blakemore, 2007). In fact Stephenson (1917), who described the species, makes no mention and Stephenson (1930: 36) merely states: "*In the Limicolae* [small aquatic microdriles, not earthworms *per se* nor in his Criodrilid] *there exists on both sides within the body-wall, in the lateral line of the body and extending through the length of the worm, a narrow longitudinal tract of cells, the cells of the lateral line. These are, as has been said, the cell-bodies of the circular muscle-layer and of the transverse muscle-bundles which stretch between the inner ends of the dorsal and ventral setal bundles of the same side. They are not, as has often been stated, nerve cells, though, according to a number of authors, ... a nerve from the cerebral ganglion does enter the line*." Justification for separation off of *Biwadrilus* on this character seemed invalid (Blakemore, 2007; 2010 cf. Sims, 1980); moreover, Stephenson (1930: 911) remarking on his *Criodrilus bathybates* under Criodrilinae further says: "*the forward shifting of the male pores is paralleled* [within the Lumbricidae] *in* Eiseniella" - thus significance in position of male pore in 13 or 15 is trivial, and species *Criodrilus bathybates* was therefore returned to its home family, Criodrilidae with *Biwadrilus* resunk in *Criodrilus*.

Michaelsen (1900: 420) had initially placed Criodrilinae under Glossoscolecidae, yet Michaelsen (1918) and Stephenson (1930: 888, 904) thought affinities of *Criodrilus* were common descent with Madagascan *Kynotus* from an original *Drilocrius*-form which probably inhabited Ethiopian Africa; they further thought *Criodrilus* was the ancestor of the Lumbricidae. In an alternative view, Stephenson (1930: 889, 904, 910) postulated that *Criodrilus* was a lumbricid modified though having adopted an aquatic life, and that origin of the Lumbricidae needed to be sought elsewhere. For Gates (1972: 50), the closest relationships of Criodrilidae, based on extra-oesophageal trunks of the

vascular system lateral to the hearts, were with the Moniligastridae (here thought highly unlikely) or Alluroididae, if not also the Haplotaxidae and the Sparganophilidae (here thought more likely). Differences in the ovaries, he believed, contraindicated close relationships between the Criodrilidae and the Lumbricidae; but Sims (1980: 114), Sims & Gerard (1985: 40; 1999: 40), and Rota & Omodeo (1992) had Criodrilidae with greater affinities with superfamily Lumbricoidea (at that time comprising of Sparganophilidae, Ailoscolecidae, Hormogastridae, Lumbricidae, and Lutodrilidae), and recent molecular analysis by Pop *et al.* (2004) seems to support similarity to, but separation from, the Lumbricidae.

Note that Sims, (1980: 108) and Blakemore (2000; 2010) put American Komarekionidae Gates, 1974 in synonymy of **Ailoscolecidae** [from Pyrenees and southeast USA composed of two genera both monotypic, viz. *Ailoscolex lacteospumosus* Bouché, 1969 and *Komarekiona eatoni* Gates, 1974] for reasons restated in Blakemore (2004, 2006). However, Reynolds & Cook, (1993) apparently maintained it and so too an amateur on the iBOL website (Ref. 2011), without any known justification, appears to attempt to maintain it (as with Biwadrilidae).

Absence of nephridia from anterior segments and loss of dorsal pores is an adaptation to aquatic life, also found in *Pontodrilus* and *Sparganophilus* and a few aquatic members of other genera; similarly, for the simplification and reduction of the digestive tract (Stephenson, 1930; M. Bouché pers. comm., 2004).

Criodrilus Hoffmeister, 1845

Criodrilus Hoffmeister, 1845: 41; Vejdovsky, 1884: 57; Michaelsen, 1900: 467; etc.
Criadilus Udekem, 1855 (laps.).
Hydrilus Qiu & Bouché, 1998 [syn. Blakemore (2007)].
Guarani Rodríguez & Lima in Lima & Rodriguez, 2007 [**syn. nov**. Blakemore, 2007)].
Diagnosis & Distribution: As per family description.
The widely distributed type *Cr. lacuum* is described below and compared to *Cr. ghaniae*.

Key to species of *Criodrilus* Hoffmeister, 1845*

1. Male pores on 13 ..... *Criodrilus bathybates***
   Male pores on 15 2
2. Dorsal pores and tubercula pubertatis (TP) absent ..... *Criodrilus lacuum*

Dorsal pores present (and TP on 30-34,35) …….. *Criodrilus ghaniae*

* *Cr. ochridensis* Georgevitch, 1950 (sometimes miscited as "Gjorgjevic, 1949") from Lake Ohrid (or L. Ochrid), Macedonia, is a dubious species according to several authors. Neither has the status of Cr. *lacuum* var. *macedonica* Ude, 1922 been resolved.

** For full description of ***Criodrilus bathybates*** Stephenson, 1917 (syn. *Cr. miyashitai* Nagase & Nomura, 1937) based on newly collected Lake Biwa material – see Blakemore (2007) where it is suggested that the biodiversity and distributions of the various species may act as indicators to monitor soil pollution and hence lake health. An interesting result of the Lake Biwa work was unexpected activity of both clitellate (breeding) adults and juveniles in an unseasonably warm winter, despite snow on the final day of survey in February, 2007 and again in winter 2010/11. *C. bathybates* mtRNA COI gene (RJB submission to Guelph Uni. April, 2011) – and this the first publication of its DNA barcode (from BOLD ref. Aug. 2011 of JET096-098) – is:

AACACTATATTTTATTCTTGGCGTATGAGCAGGAATAATTGGGGCTGGAATAAGCCTTCTAATTCGAATT
GAGCTAAGACAACCTGGTGCCTTTTTAGGAAGAGACCAACTTTACAATACCATTGTCACAGCCCATGCT
TTCATCATAATTTTCTTTTTAGTGATACCAGTGTTTATCGGGGGATTTGGAAATTGATTACTACCTTTAATA
CTGGGGGCACCTGACATAGCTTTCCCACGATTAAACAATATAAGATTTTGGCTACTGCCCCCATCCCTAA
TTCTTTTAGTATCTTCAGCTGCAGTTGAGAAGGGGGCTGGGACTGGGTGAACTGTATATCCTCCACTTG
CCAGAAACTTAGCCCACGGAGGACCCTCCGTGGATTTAGCAATTTTTTCACTTCACTTAGCTGGAGCCT
CCTCCATTTTAGGGGCTATCAATTTTATTACAACTGTAATTAATATACGATGAAACGGGCTACGCCTAGA
GCGAATCCCATTATTTGTTTGAGCCGTAACCATTACGGTTGTTCTGCTACTTCTATCCCTTCCTGTTCTAG
CTGGAGCCATTACTATGCTATTAACAGACCGAAATCTAAATACATCATTCTTTGACCCGGCTGGTGGCGG
TGACCCTGTTCTATACCAACACCTATTT

Recent return of *C. bathybates* to original genus *Criodrilus* by Blakemore (2007) appears have been ignored in some quarter (eg. BOLD ref. Oct, 2011 of un-barcoded "Biwadrilus" vouchers) for reasoning ridiculous or lacking. Moreover, having the same taxon on the same website under different names is contrary to ICZN. Nevertheless, to reiterate for the uninformed, the supposed distinguishing features of male pores in 13 rather than 15 (as found interspecifically in *E. tetraedra* for example) and supposed observation of "*lateral lines*" (as found in a fish) are dismissed as invalid morphological characters. Despite publication of this data showing no further justification for Biwadrilidae retention (e.g. Blakemore, 2006; 2007; 2010), this monotypic family yet occurs provocatively by those who should know better and set a better example! The species belongs – as was originally stated by both leading earthworm authorities, viz., Dr J. Stephenson (1917; 1930) and Dr W. Michaelsen (1921; 1928) – originally as now, in the Classical family Criodrilidae. Here are the references:

Stephenson (1917) for original description repeated in his (1930) "*The Oligochaeta*".
Michaelsen (1921): Zur Stammesgeschichte und Systematik der Oligochaten, insbesondere der Lumbriculiden. Arch. Naturgesch. 86 (1920): 130-141.

Michaelsen (1928): Oligochaeta. In Kukenthal, W. & Krumbach, T. Handbuch der Zoologie, 2(8): 1-116.

Criodrilus ghaniae (Qiu & Bouché, 1998)

Hydrilus ghaniae Qiu & Bouché, 1998: 17, fig. 1. [From Constantine, Algeria. Types in Monpellier: (H) CO-ECO 171/2860/5311; (P1-2) 2865/5311]; Omodeo, Rota & Baha, 2003/4: 463; Omodeo & Rota, 2004: 222 (both latter publications proposing synonymy of this monotypic genus and species in *C. lacuum*); Blakemore, 2006, 2007. [Note: authorship of the taxon is slightly confused as the Table of Contents (page 1) lists authors as "*Oiu Jiang-Ping, G; ouahrani et Marcel.B. Bouché."* with spelling and punctuation exactly as presented; however, publication (page 17) lists authors only as "*Jiang-Ping QIU et Marcel B. BOUCHE*" (sic) with the taxon name dedicated to "*Madame Ghania OUAHRANI* " for providing the three specimens].

Criodrilus ghaniae : Blakemore, 2007: 11. [As **comb. nov**. by Blakemore (2007)].

Diagnosis: Unpigmented. Length 125-150 mm. Segments 295-320. Prostomium epilobic (open). Dorsal pores obvious, present from 11/12. Body quadrangular. Setae closely paired, (ratio 6:1:8:1:8). Setae ab on 10-14 on large papillae, 16-22 on smaller papillae. Clitellum extensive on 22,23-34,35,36 (and with slight modification from 17-40). Tubercula pubertatis elongate and ventral to clitellum in mid-bc on 30-34,35. Female pores small lateral of b on 14; male pores on large porophores between b-c on 15; spermathecal pores absent. Longitudinal muscle fasciculated (the 'primitive' kind). Septa feeble from 4/5. Hearts 7-11. Gizzards, calciferous glands, intestinal caeca and typhlosole absent. Holoic, avesiculate. Holandric, seminal vesicles in 9-12 (those in 11-12 larger). Male pore has a "sac glandulaire au débouché du pore mâle" (= a roundish prostatic bursa). Spermathecae absent, spermatophores (form?) present in the region of the male pores.

Distribution: Constantine, Algeria.

Habitat: Limicolous, from mud of a refuse discharge channel.

Remarks: Although Omodeo *et al.* (2003, 2004: 463) and Omodeo & Rota (2004: 222) synonymized this taxon under *Cr. lacuum*, the species possibly merits restoration as *Criodrilus ghaniae* **comb. nov.**, as here, on its characteristics noted in the key and diagnosis above. Omodeo & Rota (2004: 222) question the presence of tubercula

pubertatis claiming prior inspection of specimens from Tunisia and Algeria but mention neither the dorsal pores nor nephridia (and surprisingly they failed to inspect types). Certainly it appears to belong to *Criodrilus* despite Qiu & Bouché (1998) failing to note absence (or presence?) of nephridia in anterior segments although they did state that the small nephropores were near b lines, the first in segment 4. Even so, it is not clear whether they mean in intersegment 3/4 or 4/5. Nephridia usually commence from segment 2 in Lumbricidae and further back, typically from 14-16, in Criodrilidae. As these are defining characteristics of the families, their exact origin requires confirmation from re-inspection of *Cr. ghaniae* types. Details of neither the vascular nor nervous systems were provided.

Criodrilus lacuum Hoffmeister, 1845

Fig. 5.1 *Criodrilus lacuum* figure after Perel (1979: 175, fig. 40; 1997: 50: fig. 20); other figures may be found by Google Internet search and from papers by Örley (1887) or Benham (1887) – as noted below.

Fig. 5.2 *Criodrilus lacuum* modified from Örley, 1887: 551, Pl. 38, fig. 10.

Fig. 5.3 Cocoons of *Criodrilus lacuum* from Hoffmeister, 1845, fig. 9c (no scale provided but commensurate with clitellum).

Criodrilus lacuum Hoffmeister, 1845: 41, figs. 9a-c (of habitus, anterior and two spindle-shaped cocoons http://www.regenwurm.de/pdf/hoffmeister-familie-der-regenwuermer.pdf). [Type locality Tegel-See, Berlin, Germany. Types Missing].

Criodrilus lacuum: Örley, 1887: 551, Pl. 38, figs. 1-18 [http://jcs.biologists.org/cgi/reprint/s2-27/108/551]; Benham, 1887: 561, Pl. 38, figs. 9-19 [http://jcs.biologists.org/cgi/reprint/s2-27/108/561]; Michaelsen, 1900: 468; Stephenson, 1930: 904; Gates, 1972: 50; Perel, 1979: 174; Blakemore, 2002; 2005; 2007.

Criodrilus lacuum var. *macedonica* Ude, 1922

Guarani camaqua Rodrigues & Lima in Lima & Rodrigues, 2007: 1, fig. 1. [From rice fields in Rio do Sul, Brazil. Types numbered 1-10 initially deposited in "*the Ana Cláudia Rodrigues de Lima (ACRL) collection*" although this may not be suitable under the Code (ICZN, 1999)]. **Syn. nov.** by Blakemore (2007).

[Non "?*Criodrilus lacuum*": Stephenson, 1914: 256; nec "*Criodrilus* sp. (?*lacuum* Hoffmstr.)" Stephenson, 1925: 903, fig. 13 – both reports of immature specimens from India/Pakistan = *Glyphidrilus* sp. – see Gates (1972: 50)].

Notes: As Christoffersen (2008) points out, the status of C. *lacuum* var. *macedonica* Ude, 1922 has not been resolved and it has actually been most often overlooked.

Diagnosis: In life light- or dark-brown to greenish. Length of adults 120-320 mm. Segments 200-450. Prostomium zyboloic. Dorsal pores absent. Body quadrangular after segment 9 and most noticeable posteriorly. Setae closely paired, aa>dd. Setae ab on 10-14, 17 and 19 often on small papillae. Clitellum extensive, at full development in some or all of 16-47 (i.e., up to ca. 31 segments). Female pores on 14; male pores on 15; spermathecal pores absent. Gizzards absent (or rudimentary in 12-14); calciferous glands and caeca absent. Typhlosole present or absent. Holoic, avesiculate. Spermathecae absent, spermatophores often present.

Distribution: As for family above, viz. – Tunisia and Algeria (Omodeo & Martinucci, 1987), Syria, "*Palestine*" (Israel e.g. by Pavlicek *et al.*, 2003), Lebanon; Turkey [see http://jfas.ege.edu.tr/pdf/29_Yildiz_22_1-2_2005.pdf], southern Russia; Hungary (Budapest); Bulgaria (Lake Srebarna), Greece, Yugoslavia; Italy (Pavia, Treviso, Turin), Austria (Linz); Germany (Berlin); Rivers and tributaries of Danube and Po (e.g. Örley, 1887); France; Spain, Portugal, Latvia; Poland; Moldavia; Amur region of Siberia. Introduced into America [plant pots, Baltimore (Gates, 1972) and rice fields Brazil: Rio Grande do Sul (Knäpper & Porto, 1979; Lima & Rodriguez, 2007)]; UK (unconfirmed cf. *Anagaster fontinalis* Friend, 1921 above); India (unconfirmed cf. Julka, 1988: 39); Japan.

Materials examined and localities: Not found in current studies in Australasia/Asia.

Habitats: Mud of fresh and brackish waters (in roots of *Sium latifolium* L. in Europe).

Behaviour: Semi-aquatic; tail often protrudes above substrate (as in *C. bathybates* for oxygenation?); and regeneration, particularly of 'tail' segments, common (Örley) while Tirala (1912) and Gates (1972) notes anterior 'head' regeneration from as far back as 40/41 in *Cr. lacuum*.

Length: 40-320 mm.

Width: 4-10 mm.

Segments: 200-450; body quadrangular (after segment 9) and grooved dorsally on and after clitellum (to increase surface area for gas exchange).

Colour: In life, light- or dark-brown to greenish; or colourless.

Prostomium: Zygolobous (cf. epilobous in *Hydrilus*).

First dorsal pore: None (cf. 11/12 *Hydrilus*).

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment, fairly closely paired (dd>aa).

Nephropores: In b lines (none in anterior).

Clitellum: Multilayered, annular in some or all of (14,15),16 - ca. 45; perhaps less detectable in some specimens to give variable (and unreliable) counts (e.g. *Guarani*).

Male pores: On large muscular porophores on 15, approximately in b lines (the "vulva" of Hoffmeister) which probably serve for construction of the cocoon.

Female pores: In 14 or towards 14/15 often on small tumescences near b lines (reported median to a lines in *Guarani*).

Spermathecal pores: Absent (cf. Örley as noted in Remarks below).

Genital markings: Tubercula pubertatis absent (cf. reported on 30-34,35 in *Hydrilus*); some setae in genital tumescences, e.g. some of 9,10-13,14, 17 and 19.

Septa: Feeble.

Vascularization: Single dorsal blood vessel complete, along with ventral subneural and supraoesophageal vessels.

Hearts: (6?),7-11.

Gizzard: Oesophageal and intestinal gizzards absent [but some thickening of oesophagus in 5-7 and intestine in 15-20,21 (Sims), or slightly muscular in 12-14 (Michaelsen)].

Calciferous glands: None.

Intestine origin (typhlosole): Crop in 14-18 and intestinal origin in 19 (Benham), although it is sometimes quoted as between 13-18. Typhlosolate according to Benham and others, atyphlosolate by some authors, more often not noted.

Nephridia: Holoic from 13 (sometimes nephridia reported only after 15 or 16), avesiculate (cf. *Sparganophilus*, *Pontodrilus*).

Male organs: Holandric; seminal vesicles four pairs in 9-12 (developed in just 11 & 12 in *Guarani*).

Ovaries: Fan-shaped in 13; ovisacs large in 14. Ova not yolky.

Prostates: Bursae or 'prostatic glands' in 15.

Spermathecae: Spermathecae absent [strangely, Örley (1887: 554) described them ventrally between segments 9/10 and 10/11 and he speculated that they produced the spermatophores, but since no other author found these it is possibly a mistake as suggested by Benham (1887: 569)]; spermatophores (Hoffmeister's "*penis-formige Ktirpehen*"), hornshaped, tubular or saccular, attached externally and usually ventrally although occasionally dorsally near male pores.

Gut contents: ?

Cocoons: "*spindle-shaped, parchment like structures with a colour that changes; they are about 5 cm. in length, rapidly diminishing towards each end. One end, drawn out into strongly fibrous threads, serves for attachment to the roots, or more rarely to the leaves and branches of water plants; the other end truncated, with a dentate edge, allows the embryos to escape. As is the form, so also is the colour different. The perfectly newly laid cocoons are nearly transparent, horny yellow in colour, but after a time they become darker, and towards the time of hatching of the embryos they are blackish in colour.*" (Örley, 1887: 556).

Remarks: German types were supposedly atyphlosolate like those from Bohemia; while Italian specimens (all?) have a thick typhlosole. Genital setae are reported to have ectal grooving that supposedly demonstrates that *Criodrilus* is closely related to the Lumbricidae.

Guarani camaqua is combined as its justification relies on seminal vesicles in only 11 and 12, even though these vary at interspecific level and are certainly irrelevant at genus level, also Benham (1887: 567), at least, told us they are "*one on each side of each of the somites ix, x, xi, and xii ; they vary in size in these somites, and in different individuals*". As to its blood vessels: the vascular systems of classical taxa, especially those lacking types such as *Cr. lacuum*, are often poorly defined, however, on this point, Benham (1887: 566) at least reported "*The vascular system I have not traced to any extent.... A subneural vessel is present and a typhlosolar vessel, but neither latero-neural nor intestino-tegumentary vessels exist*" and it is perhaps rather irrelevant whether subneural vessels are attached or not. Moreover, there is a prior report of *Cr. lacuum* from Rio Grande do Sul, Brazil by Knäpper & Porto (1979) that Lima & Rodriguez (2007) seem not to have compared to their rice field specimens, even though such an unnatural habitat should initially suggests an introduced, exotic taxon rather than a new native.

Criodrilus lacuum is diploid with chromosome number is 22 (Omodeo, 1984). Recent 18S, 16S rDNA and cytochrome c oxidase sequences molecular studies by Pop *et al.* (2004) show that *Criodrilus lacuum* is relatively primitive compared to lumbricids and is an adelphotaxon (or sister taxon) of either of two lumbricid species: *Eiseniella tetraedra* (Savigny, 1826) or *Aporrectodea dubiosa* (Örley, 1881) [now in *Eophila*], that both share with it an aquatic habitat.

Ecology: Breeding occurs from March to July in Europe (Örley). In Italy *Cr. lacuum* is often associated with *Eiseniella neapolitana* (Örley, 1885) and *Haplotaxis gordioides*

(Hartmann, 1821) (not Omodeo, 1984!), and Örley (1887: 560) describes it with his *Aporrectodea dubiosa dubiosa* (Örley, 1881) and he also reports that "*amongst the Hirudinea, species of* Aulostoma *and* Nephelis *are their greatest enemies; these swallow three or four Criodrili at a time*". Benham (1887) noted presence of common parasitic gregarines near the ovaries in segment 14. Regeneration capacity is high and rapid, perhaps in response to predation relating to its behaviour, as already noted, of protruding its tail above the substrate and its attack by leeches.

For 44 years Dr Tarmo Timm (pers. comms. July, 2007, Jan, 2009) maintained laboratory cultures of specimens of this species in separate aquaria (see 'Longevity' section above for details or read Blakemore, 2007).

Family **Sparganophilidae** Michaelsen, 1918

Rhinodrilidae (part?) Benham, 1890: 222.

Criodrilidae (part) Michaelsen, 1900: 463.

Sparganophilidae Michaelsen, 1918: 301, 1921: 86, 1928: 107; Stephenson, 1930: 899; Gates, 1972: 314, 1982: 29; Sims & Gerard, 1985, 1999: 120; Blakemore, 2000, 2006, 2008, 2010.

Type-species and type-genus: *Sparganophilus tamesis* Benham, 1892 by monotypy.

Etymology: The generic name refers to the type-habitat: "*amongst the roots and the lower parts of the leaves of the bur-reed (*Sparganium ramosum*), which grows in black, evil-smelling mud on the banks of the Thames*."

Diagnosis (from Eisen, 1896; Gates, 1972: 314; Reynolds, 1977: 112; Sims, 1980: 107; Sims & Gerard, 1985, 1999: 120): Limicolous in freshwater. Body cylindrical but capable of forming dorsal groove. Lateral line doubtfully present (Sims, 1980: 107). Setae lumbricine. Dorsal pores absent or present only in anterior (e.g. 1/2-5/6). Pigment lacking. Clitellum multilayered saddle-shaped (*S. tamesis*, *S. pearsei*) or annular (*S. smithi*) in (14),15-25,26,(27,28), paired tubercula pubertatis present. Female pores on 14. Male pores inconspicuous in 18/19 or on 19. Spermathecal pores paired, occasionally multiple, inconspicuous in (5/6)6/7/8/9. 'Prostate-like glands' present usually four or five pairs, but not associated with male pores. Spermathecae present, one to four pairs per thecal segment; adiverticulate. Oesophageal and intestinal gizzards, calciferous glands, caeca and typhlosoles absent. Intestinal origin (in 7-9) in front of testis. Hearts in 6,7-11. Nephridia holoic, aborted at maturity in first twelve or more segments; avesiculate. Ovaries with single egg-strings in 13. Ova not yolky.

Distribution: North and Central America [e.g. Great Lakes, Ontario, New Brunswick, N.Y., New Jersey, Florida, Michigan, North Carolina, Louisiana, Tennessee, Texas, California, Oregon, Guatemala, Guayana (sp unknown, Ref), Mexico]; type-species (?re-)introduced to England, France, Germany and Switzerland. Single genus accommodating a dozen or more Nearctic species (Sims & Gerard, 1985: 120; Blakemore, 2007). Mostly limicolous (mud-dwelling) or semi-aquatic. A report from the Western Ghats, India of "*Sparagnophilus sp*." (sic) is unconfirmed but, if true, it is probably introduced.

Notes: The type-species, *Sparganophilus tamesis* Benham, 1892, is limicolous and relatively rare but is endemic to Great Lakes, Mississippi and east coast to Guatemala and has been (?re-)introduced, probably among the roots of water plants, into England,

France (once to Lorraine) according to Sims & Gerard (1985, 1999), to Germany (River Alster in Hamburg (U. Graefe pers. comm.) and to Lac Léman (Lake Geneva) Switzerland (Zicsi & Vaucher, 1987; plus Qiu & Bouche, 1998).

Since Michaelsen (1900) *Sparganophilus* had been associated with the Glossoscolecidae, but more recently, based on the shape of the ovaries, Gates (1972: 315) thought Sparganophilidae and Lumbricidae have common but distant ancestry, while Sims (1980) and Sims & Gerard (1985) have *Sparganophilus* in superfamily Lumbricoidea. Monotypic Amazonian taxon *Areco reco* Righi, Ayres & Bittencourt 1978 may be related. A supposedly endemic Swiss species, *Sparganophilus langi* Bouché & Qiu, 1998: 179 in Qiu & Bouché (1998) from Lac Léman is a new synonym.

Sparganophilus Benham, 1892

Sparganophilus Benham, 1892: 155; Eisen, 1896: 151; Michaelsen, 1900: 463; Gates, 1972: 314, 1982: 29; Sims & Gerard, 1985, 1999.

Diagnosis & Distribution: As per family description.

Sparganophilus tamesis Benham, 1892

Fig. 5.4 *Sparganophilus tamesis* [figure modified from Worm Watch Canada website http://www.naturewatch.ca (no scale provided)]. Cf. Original figures from Benham, 1892, Beddard (1896) and Fig. 43 from Sims & Gerard (1999: 121).

Sparganophilus tamesis Benham, 1892: 156. [Type locality Goring-on-Thames, downstream from Oxford Botanic Gardens. Types British Museum (subadults) 1892:12:16:1-2]; Eisen, 1896: 153; Michaelsen, 1900: 463; Brinkhusrst, 1971: 50; [syn. *cuenoti*, *eiseni*, ?*elongates* (sic laps. pro *elongatus*)]; Reynolds, 1980: 190; Gates, 1982: 29 (where he says: "*Brinkhurst (1971) thought* eiseni *is a synonym of* tamesis *which was unacceptable to Reynolds (1980: 199)*"; Sims & Gerard, 1985/1999: 120, fig. 43 (syn. *eiseni*, *elongatus*, *cuenoti*).

Sparganophilus eiseni Smith, 1895: 142 [From Illinois and Florida. Types lost]; Gates, 1943: 94; 1972: 314 [syns. *benhami* + varieties (*guatemalensis* & *carnea*), ?*cuenoti*]; Michaelsen, 1900: 464; Olsen, 1940, fig. 1; Reynolds 1977: 113, fig. 40 (syn. *elongatus*, *cuenoti*); Reynolds, 1980: 191; Gates, 1943: 94; 1985: 29; McAlpine *et al*., 2001 (new record from New Brunswick, Canada).

[Consistenly misspelt "*thamesi*" in Qiu & Bouche (1998: 180)].

Sparganophilus benhami Eisen, 1896: 154,161. [From Mexico. Types?]. [Non *Thamnodrilus benhami* Cognetti, 1904 (= *Rhinodrilus*/*Martiodrilus benhami*)].

Sparganophilus benhami var. *guatemalensis* Eisen, 1896: 155,167. [From Guatemala. Types lost].

Sparganophilus benhami var. *carneus* Eisen, 1896: 155,168. [From Iowa. Types lost].

Helodrilus elongatus Friend, 1911: 146, 192. [Types BMNH 1923:12:31:267-7; Reynolds & Cook (1976: 98) list this taxon as *Sparganophilus elongatus* Friend, 1921: 137 (perhaps his redescription?)].

Sparganophilus elongatus: Friend, 1921: 137; Brinkhurst, 1971; Reynolds, 1980: 198.

Pelodrilus cuenoti Tétry, 1934: 322-324. [Reynolds & Cook (1976: 92) list type as British Museum: 1949:3:1:190].

Sparganophilus langi Bouché & Qiu, 1998: 179, fig. 1 in Qiu & Bouché (1998). [From Lac Leman at two sites; types in CO-ECO; syn. nov. Blakemore, 2010].

Taxonomic Note: In synonymy of *S. tamesis* are *S. eiseni* Smith, 1895; *Helodrilus elongatus* Friend, 1911; and *Pelodrilus cuenoti* Tétry, 1934 – according to Sims & Gerard (1985; 1999) – plus *S. langi* was a **new synonym** by Blakemore (2010) for reasons given in Remarks below. Earlier, Gates (1972: 314) had included *S. benhami* Eisen, 1893 plus its sub-species in *S. eiseni* (= *S. tamesis*) but questioned whether *cuenoti* belongs in the genus since the type description implied male pores are in 11 or 12, cf. on 19 in *S. tamesis*. Some American authors maintain *S. eiseni* in defiance of Sims & Gerard's (1985; 1999: 122) explanation of its synonymy in *S. tamesis* (also given below).

Diagnosis: Length 70-200 mm. Unpigmented but sometimes pinkish with blue-green iridescence. Prostomium zyboloic. Body cylindrical but capable of forming dorsal groove. Dorsal pores absent (mostly). Clitellum saddle-shaped (14),15-25,26,(27); tubercula pubertatis present along edge above b lines for most of length (e.g. 15-24 or at least 19-22). Female pores on 14 in a; male pores inconspicuous, lateral on 19 in bc; spermathecal pores 6/7/8/9 above c lines. Holoic but nephridia absent from anterior.

Distribution: Relatively rare but widespread (most likely due to introduction above the line of glaciation) in North America mostly east of the Mississippi to Central America [e.g. Quebec, Lake Erie, Lake Ontario, St Lawrence River, New Brunswick, Illinois, Wisconsin, Michigan, New Jersey, New York, Massachusetts, Iowa (*benhami*), Missouri, North Carolina, Louisiana, Tennessee, Texas, Florida, also Oregon(?), California(?),

Guatemala (*benhami*), and Mexico (*benhami*)]; introduced to England (e.g. Thames, Cheshire meres, Lake Windermere), France (*cuenoti* from Lorraine?), to Germany (River Alster in Hamburg (U. Graefe pers. comm.), northern Italy (E. Rota pers. comm.), Lac Leman (= Lake Geneva) Switzerland (as *langi* but also see Zicsi & Vaucher, 1987). These reports are from Smith (1895), Eisen (1896), Michaelsen (1900), Tetry (1934), Gates (1972), Reynolds (1977, 1980 with misleading key, 2008), Sims & Gerard (1985; 1999), Zicsi & Vaucher (1987) and Qiu & Bouche (1998).

Localities: Not found in current studies in Australia/Asia.

Habitats: Limicolous, in mud of watercourses, and in adjacent saturated soils, plant roots; also in tanks containing water plants (e.g. Kew, Middlesex and Cornwall in UK).

Behaviour: Limicolous (mud-dwelling) or semi-aquatic.

Length: 70-200 mm. **Width:** 1-5 mm.

Segments: 125-260; body circular but capable of forming dorsal groove.

Colour: Unpigmented but sometimes pinkish with blue-green iridescence.

Prostomium: Zygolobous.

First dorsal pore: Absent or present only in anterior (e.g. 1/2-5/6).

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment, closely paired; (aa=bc, dd>0.5U).

Nephropores: Inconspicuous in ab lines (none in anterior to around 13 or 14).

Clitellum: Multilayered, saddle-shaped (14),15-26,(27).

Male pores: Inconspicuous on 19 between bc setal lines; cf. pores of 'prostate-like glands' often in some of segments 22,23-26 in front of b setae. [Note: Sims & Gerard (1999: 120) have "*usually 4 pairs*" .. "*on several segments xvii-xxvi*" which is probably a mistake for "xxii-xxvi" i.e., 22-26 once again showing the problem of Roman numerals].

Female pores: In 14 in front of setae a.

Spermathecal pores: Minute in 6/7/8/9 in or just above setal c lines (plus on unilateral on rhs in 5/6 in at least one Lac Leman specimen of *langi* synonym).

Genital markings: Tubercula pubertatis present along edge above b lines for most of length (e.g. 15-24 or at least 19-22); ventral setae in genital tumescences in 16 (and adjacent segments).

Septa: From 4/5; 5/6-9/10 substantive.

Dorsal blood vessel: Complete, along with ventral vessel; subneural and supra-oesophageal vessels absent.

Hearts: Commissurals or connectives of dorsal and ventral vessels in all of 1-6; lateral hearts in 7-11.

Gizzard: Oesophageal and intestinal gizzards, calciferous glands, and caeca absent (but some thickening of oesophagus in 5-7 and intestine in 15-20,21).

Calciferous glands: Absent.

Intestine origin (caeca, typhlosole): In 7-9 ("7" or "VIII" *langi*); typhlosole absent.

Nephridia: Holoic from 13, avesiculate (cf. *Criodrilus*, *Pontodrilus*).

Male organs: Holandric; seminal vesicles four pairs in 9-12 (latter two pairs larger).

Ovaries: With single egg-strings in 13; ovisacs small in 14. Ova not yolky.

Prostates: 'Prostate-like glands' with muscular ducts paired e.g. in 13-16 (*eiseni*), 22-26 (*tamesis*) or 23-26 (*langi*).

Spermathecae: Three pairs in 7-9, pear-shaped with long duct, adiverticulate.

Gut contents: Mud?

Cocoons: Sausage shaped, frayed at one end and drawn out slightly at the other (Benham, 1892: fig. 4).

Remarks: This species (or *S. eiseni* at least) is stated to be amphimictic. Musculature is fasciculated (Gates, 1972: 315). Almost certainly introduced to type-locality in UK as : "*The worms were all found in a backwater some little distance below Goring, and I could find none elsewhere, though I examined similar spots on the banks both above and below this backwater, as well as in the river near Oxford. Moreover these worms appeared to be limited to an area of about ten yards in length along the bank, for repeated examination of this backwater met with constant failure with the exception of this prescribed area*."

Sims & Gerard (1985, 1999: 122) explain how "*Some European specimens (including the sub-adult types) were separated specifically from the North American populations owing to a misinterpretations of variations due to growth and the diverse effects of differing techniques of fixation and preservation (Reynolds, 1980). There are also minor (?phenotypic) setal differences (Fender, personal communication)*."

Although Eisen (1896) thought that a large number of species would soon be found on the American continent, this has barely occurred – just 14 are listed by Blakemore, 2007) – mainly due to a "*derogation of systematics and in particular that of the Oligochaeta*" (Gates, 1972: 315).

Justification for the *S. langi* Bouché & Qiu, 1998 synonym on supposed slight differences in setal ratios – themselves notoriously unreliable characters, and as alluded to above in *Sp. tamesis* – plus an abnormal extra spermatheca that was atrophied in the anterior of segment 6 rhs, are insufficient to consider it distinct from all or any prior taxa.

It is newly absorbed and may be considered an introduction to Switzerland (that was heavily glaciated in the Pleistocene), by mecanisms similar to those for specimens collected from England, France and northern North America, as indeed its presence in Lac Léman was already noted by Zicsi & Vaucher (1987) 10 years earlier!

Family **Hormogastridae** Michaelsen, 1900

Rhinodrilidae (part) Benham, 1890: 222; Hormogastrinae Michaelsen, 1900: 446. [Misspelt "Hormogostridae" by Qiu & Bouché (1998: 1). Sub-families HORMOGASTRINAE Michaelsen, 1900 [for *Hormogaster* Rosa, 1887 and *Hemigastrodrilus* Bouché, 1970], VIGNYSINAE Bouché, 1970 (for *Vignysa* Bouché, 1970), and XANINAE Diaz Cosin *et al.* 1989 (for *Xana* Diaz Cosin *et al.* 1989)].

Type-genus: *Hormogaster* Rosa, 1887 (syn "*Hormodrilus*" laps. Rosa (1889: 54)).

Diagnosis (Michaelsen, 1900): Terrestrial. Setae lumbricine (closely to widely paired). Female pores on 14. Male pores intraclitellar (ca. 15/16). Spermathecae present or absent. Gizzards multiple two to three of in 6-8. Last hearts in 11. Holoic vesiculate.

Distribution: Mediterranean, ca. 28 taxa in 4 genera; one species, *Hormogaster redii*, possibly introduced to north Africa (Tunisia and Algeria) with one record of transport to North America from Italy (Gates, 1954: 248; 1972: 61), but the species is not established in USA. See also Rota (1994).

Key to common species (after Michaelsen, 1900)

Setal ratio in midbody with cd>bc (spermathecae present)..... *H. redii* Rosa, 1887

Setal ratio in midbody with cd<bc (no spermathecae?) .. *H. pretiosa* Michaelsen, 1899

Hormogaster redii Rosa, 1887

Hormogaster redii Rosa, 1887: 1. [Type in Turin 332]; Michaelsen, 1899: 445; 1900: 446; Gates, 1954: 248; Blakemore, 2004: 80, 2007, 2006, 2008, 2010. [Subspp are ***H. redii gigantea*** Michaelsen, 1917 (sometimes misspelt "*gigantes*") ~750 mm long, and ***H. r. insularis*** Bouché, 1970].

Diagnosis: Length 160 mm, width 8-9 mm. Segments 300-380. Brownish. Prostomium prolobous. Dorsal pores absent (as per family). Setae in 2-6 laterally disposed and widely paired, in 7-10 more closely paired with ab=bc. Setae in clitellar region modified as genital setae. Clitellum saddle-shaped in 14,15-25. Tubercula pubertatis in18,19-24,25. Male pores lateral of setal b lines in 15/16. Spermathecal pores three pairs in 9/10-11/12 in cd lines. Seminal vesicles in 11 and 12 racemose. Septa 6/7-8/9 thin. Gizzards three of, strong, in segments 6-8. Spermathecae oval (adiverticulate). Prostate-like bursa absent.

Distribution: Italy, Sardinia, Sicily; Tunis (Tunisia) and Algeria, intercepted in U.S.A. in "*soil with citrus tree, in baggage from Italy arriving on S/S* La Guardia *at New York, Nov. 8, 1950, 2 clitellate specimens*" but not domiciled there (Gates, 1954; 1972: 61).

Family **Lumbricidae** Rafinesque-Schmaltz, 1815

Lumbricidae Rafinesque-Schmaltz, 1815; Claus, 1876: 416; Michaelsen, 1900: 470; Stephenson, 1930: 905; Gates, 1972, 1982; Blakemore, 2007. 2010.

Type-species and type-genus: *Lumbricus terrestris* L.

Diagnosis: Setae lumbricine. Dorsal pores present (paired lateral analogues in Diporodilinae). Clitellum usually saddle-shaped, behind segment 17 (rarely 15). Female pores on 14. Male pores usually paired on 15 (rarely in any of 11-14 or 16 in parthenogenetic morphs, especially of *Eiseniella tetraedra*), or inconspicuous and intraclitellar (in *Cernosvitovia*, *Fitzingeria*, *Octodriloides*, *Postandrilus*). *Orodrilus* spp have preclitellar male pores and are similar to *D. byblica* spp except for their meroandry. Adiverticulate spermathecae, when present, occur between 5/6-19/20 (most commonly dorso-laterally in 9/10/11); spermatophores may also occur. Prostates, oesophageal gizzards and intestinal caeca absent. Intestinal gizzard single mostly in segment 17 or in two to four segments between 17-20 (entirely confined to 17 in *Eiseniella* and several species of *Bimastos, Eisenia* and some members of the *A. caliginosa* species group); calciferous glands intra- or extra-mural in some of 9,10-14,15. Intestine typhlosolate. Last hearts before 12. Nephridia holoic and, except for *Helodrilus* (and *Proctodrilus*), vesiculate.

Another characteristic of the family is having male and female pores in setal *bc* lines, except for *Eiseniella* morphs, *Healyella* and some*Bimastos* that have them in *ab.*

Subfamilies: LUMBRICINAE [?including subfamilies EISENIINAE Omodeo, 1956 (for *Eisenia, Eisenoides, Dendrodrilus, Omodeoia*); SPERMOPHORODRILINAE Omodeo & Rota, 1989 (for genera *Spermophorodrilus* Bouché, 1975 and *Healyella* Omodeo & Rota, 1989 that are both considered poorly defined by Csuzdi *et al.*, 2017) and POSTANDRILINAE Qiu & Bouché, 1998 (for *Postandrilus* Qiu & Bouché, 1998, *Cernosvitovia* Omodeo, 1956, plus *Fitzingeria* Zicsi, 1978 and *Zicsiona* Mrsic & Sapkarev, 1987, and possibly also admitting *Octodriloides* Zicsi, 1986 – this latter subfamily, at least, was considered too polyphyletic to be acceptable to Csuzdi & Zicsi, 2003: 23); ALLOLOBOPHORINAE Kvavadze, 2000: 80 [stated to consist of *Allolobophora, Dendrobaena, Octolasion, Eophila, Bimastos, Eiseniella, Cernosvitovia, Microeophila, Octodrilus, Eiseniona, Kritodrilus, Scherotheca, Opothedrilus, Proselodrilus, Orodrilus, Ethodrilus* (sic for *Ethnodrilus*), *Satchellius, Murchieona, Fitzingeria, Octodriloides, Zicsiona, Alpodinaridella, Dinaridella, Crniella* Mrsic, 1987 (sic for *Creinella* Mrsic, 1986)*, Meroandriella, Serbiona,*

Italobalrniona (sic for *Italobalkaniona*), *Panoniona, Karpatodinariona, Allolobophoridella, Dendrodriloides, Caucasodrilus*]; HELODRILINAE Kvavadze, 2000: 82 (consisting of *Helodrilus* and *Proctodrilus*)], and DIPORODRILINAE Bouché, 1970 (for Corsican species with paired lateral pores rather than dorsal pores)]. Note: Sims & Gerard (1999: 46) mistakenly say that only Diporodrilinae is characterized by a single intestinal gizzard in two segments, actually this is typical for most Lumbricidae, as noted by Csuzdi & Zicsi (2003: 30). Originally as a new family: Diporodrilidae, miscited as "*Diporochaetidae*" by Reynolds & Cook (1981: 1); reduced to sub-family by Easton (1983: 475), its re-elevation to family status proposed in Qiu & Bouché (1998: 198) is not supported by Csuzdi & Zicsi (2003) nor here.

Distribution and diversity: Palaearctic and North America (Holarctic), possibly disjuncted by epicontinental seas on Laurasia in the Jurrasic/Cretaceous (Bouché, 1983), and only surviving below the southern limits of Pleistocene glaciation (except in isolated refugia?); thus those now found north of the former ice-sheet line are often (always?) peregrine species [Michaelsen (1902, 1903) – from Csuzdi & Zicsi, 2003 who also show four great domains of endemic lumbricids]. After synonymizing of *Allolobophora indicus* (Michaelsen, 1907) [see *A. rosea*], Gates (1958) reviewed lumbricids exotic to the Orient and Gates (1972: 108) thought the southern boundary in Asia is north of the Hindu Kush and Karakorum ranges and from Baluchistan west to the Pacific, indeed he thought endemicy of any lumbricid south of Tian Shan and Altai Mts, Mongolia and Manchuria would be quite unexpected. American endemics are mostly confined east of the Allegheny Mts., the only wholly endemic North American genus is *Eisenoides* Gates, 1969, 1982 (cf. James, 1990: 379 who misleadingly states: "*There is only one native terrestrial genus of Lumbricidae,* Bimastos"), while *Bimastos* apparently shares similar species with the Mediterranean (e.g. see Csuzdi & Pavlicek, 1999 although Pavlicek, pers. comm. 2011, says Middle East species should probably go into a genus other than *Bimastos*), as did (does?) the Palaearctic *Dendrodrilus*, at least prior to North American glaciation (Schwert, 1990: 344).

The family range ccurrently extends from Vancouver Island [*Bimastos lawrenceae* Fender, 1994 - the only lumbricid endemic to Canada] to Korea and Japan [viz. *Eisenia koreana* (Zicsi, 1972), that is sometimes returned to *Eiseniella*, *Eisenia japonica* (Michaelsen, 1892) – the only lumbricids supposedly endemic to Korea and Japan – plus *Helodrilus hachiojii* Blakemore, 2007 and *Eisenia anzac* Blakemore, 2011

only from Japan and several other lumbricids recently described by the author]. Peregrines, numbering around 33 species from several genera, are very widely distributed (Lee, 1987; Blakemore in current works). Despite their worldwide distribution, Gates (1972: 63) states that "*No lumbricid species is known to have colonized tropical lowlands permanently, anywhere. Deliberate introductions by the hundreds, if not thousands of individuals, failed*." However, the present study seems to contradict this general statement for certain species (e.g. *A. trapeziodes*, *E. fetida*, and *Ei. tetraedra*) although only a few of these have been deliberately introduced. The Lumbricidae is believed to be relatively recently evolved from aquatic precursors but is not considered as 'advanced' as Eudrilidae that has direct internal fertilization.

Current figures are of ~670 valid names from a total of some 1,150 nominal taxa (Blakemore, 2004; 2007) cf. Easton's (1983) checklist of just ~386 lumbricids.

Enigmatic *Eophila eti* Blakemore, 2008 is a probable introduction to Tasmania from Europe since an endemic lumbricid from that island State would be highly unexpected.

Lumbricid Nomenclature and Systematics [skip to keys]

Despite a long history with numerous revisions, lumbricid taxonomy remains in an uncertain state with parochial or superseded references being perpetuated and misconceptions or contradictions maintained. Thus parts of the literature are incompatible with other parts in giving the same species different names and *vice versa*. Revisions of Michaelsen's (1900) system (e.g. by Pop, 1937, 1941; Omodeo, 1956; Bouché, 1972; Gates, 1972; Perel, 1976, 1979; Zicsi, 1982; Sims & Gerard, 1985, 1999) have refined several genera. The generic definitions here are based on those of Gates, as adopted by Sims & Gerard (1985; 1999: 44) or Csuzdi & Zicsi (2003). But Easton's (1983) listing of valid species names and reallocation of several taxa without redefinition again cast some generic diagnoses into a confused and non-mutually-exclusive state (cf. Blakemore, 2004a; 2007; 2008).

Residual conflicts in the correct placement of species are exemplified when trying to find a 'happy home' for Savigny's *rosea*. Gates (1974a) wrote that "*Eisenia rosea has been widely misunderstood in the past, the species or individuals of it have been referred to 8 genera, 3 sub-species and 10 varieties...as well as with 10 or more species names*"; nevertheless, he confirmed *E. rosea* in *Eisenia*. However, later Gates (1977) recanted and stated "*A. rosea did not belong in the genus... but may not belong in*

Aporrectodea either" although this is where he placed it. Certainly, '*A. rosea*' by any other name would still be the same, so is herein retained in *Aporrectodea* as by Sims & Gerard Previous concepts had given weight to dorsal or lateral position of spermathecal pores, while more recent generic diagnoses (e.g. those presented by Sims & Gerard, 1985) for *Eisenia* are: calciferous gland opening into the oesophagus in 11, nephridial vesicles "*sausage-shaped*", pigment red; and for *Aporrectodea*: calciferous glands opening in 10, nephridial vesicles "*U-shaped*" and pigment, if present, not red. However, red or pink pigmentation is a variable character which is present in *E. fetida* and in live specimens of *A. rosea* (hence its name!), e.g. the diagnosis by Easton (1981: 44) has it "*unpigmented, anterior segments dark red, rest of body pink or pinkish grey*". Some other members assigned to these genera by Easton (1981; 1983) have characters which overlap, for instance, *Eisenia japonica* has morphs varying in several characters (e.g. unpigmented and/or with spermathecae in c setal lines), whereas several members of *Aporrectodea* such as *A. icterica* and *A. limicola* have pink colour and spermathecal pores in cd lines. Moreover, despite their claim to have unravelled this taxonomic tangle, the diagnostic of *Eisenia* by Sims & Gerard (1985, 1999: 43, 79) is somewhat invalidated by their retention in this genus of species such as *hortensis* and *veneta* that are more appropriately placed in *Dendrobaena*.

Much uncertainty and contradiction persists in definitions of *Aporrectodea caliginosa* and *Aporrectodea trapezoides* (e.g. Cain, 1955; Gerard, 1964; Gates, 1972, 1972a; Reynolds, 1977; Martin, 1977; Sims & Gerard, 1985; Schwert, 1990). Recognizing the affinities and distinctions between related species, Gates (1972: 69; 1972a) proposed a peregrine "*Allolobophora trapezoides* group" which included *Allolobophora limicola, A. longa*, *A. nocturna*, *A. trapezoides*, *A. tuberculata* [cf. *caliginosa*], *A. turgida* [= *caliginosa*], and possibly several other species. Easton (1981) defined Gates' grouping as a "Aporrectodea trapezoides *species-complex*" but also described *A. caliginosa* and *A. trapezoides* separately. Sims (1983: 469) stated that "*Nowadays (Zicsi, 1982),* caliginosa *Savigny, 1826 includes* trapezoides *Dugès 1828;* tuberculata *Eisen, 1874 (non* tuberculata *Cernosvitov, 1935);* nocturna *Evans, 1946 and* turgida *Eisen, 1873*". Yet only a few pages later, Easton (1983) provided a guide to the valid names of Lumbricidae that listed separate synonymies for both *A. caliginosa caliginosa* (Savigny, 1826) (including *turgida* and *tuberculata*) and *A. caliginosa trapezoides* (Dugès, 1828). Contradiction is again found in Sims & Gerard (1985, 1999), who advocated placing several 'morphs' or 'phases' in the synonymy of *A. caliginosa*

(syn *A. turgida*), including *A. tuberculata*, *A. nocturna*, *A. trapezoides*, but possibly excluding *A. nocturna* for ecological reasons. Nevertheless, Sims (1983: 469) and later Sims & Gerard (1985; 1999: 44) clearly state that *caliginosa* retains priority over *turgida* by "*subsequent restriction and usage by other authors, e.g. Michaelsen (1900), that validate the application of Savigny's name of the grey worm or turgid worm as it was once known to anglers*". [Note: Savigny's adjective '*caliginosus*' in Latin means 'misty'or 'obscure'; ironically, the verb root can mean "*causing dizziness*"].

According to Sims & Gerard (1985; 1999: 44) some North American authors incorrectly cite *Aporrectodea turgida* (Eisen, 1873) and/or *A. tuberculata* (Eisen, 1874) in preference to the prior *A. caliginosa* (Savigny, 1826) on the grounds that Savigny did not clearly define his species whereas Eisen's material permits adequate charcterization (e.g. see Gates, 1972; Reynolds, 1977; James, 1990: 381). Other authors, such as Schwert (1990: 355) acknowledge *caliginosa* but also retain *tuberculata*. Yet there is an abundance of other available names that may equally compete for precedence under the ICZN Principle of Priority, albeit they are usually included in synonymy of *caliginosa*, e.g., *carneum* Savigny, 1826; *lividus* Templeton, 1836; *gordianus* Templeton, 1836; *purus* Dugès, 1837; *hortensiae* Kinberg, 1867; *novaehollandiae* Kinberg, 1867; *communis olivaceus* Eisen, 1871; and/or *pellucidus* Eisen, 1871. Some of these names may have been erected or applied at different times to the various intermediate ecotypes, parthenogenetic morphs and phenotypic variants that are known within the *caliginosa*-complex. Thus, after a century of reshuffling, the pragmatic solution is to revert to that already advocated by Michaelsen (1900: 483) who, with a World view rather than a restricted wholly northern European/North American stance, separated *caliginosa* Savigny, 1826 (syn. *turgida*) and *trapezoides* Dugès, 1828 as distinct taxa.

Allolobophora previously included numerous taxa, but is more restricted since A. *chlorotica* was designated the type-species (Omodeo, 1956), and several earlier inclusions are now reallocated to *Eisenia* or *Aporrectodea*. In Easton (1983) *Allolobophora parva* Eisen, 1874 replaced *Bimastos parvus* and its erstwhile synonym, *B. longicinctus*, was removed (provisionally) to *Eisenia*. However, various workers use either name (eg Gates, 1972; Easton, 1981, Sims & Gerard, 1985; Temirov & Valiakhmedov, 1988; James, 1990; Schwert, 1990); cf. Csuzdi & Zicsi (2003: 69) and Csuzdi *et al*. (2017) who retain *Bimastos parvus*, as herein. Rosa's *constricta*, included by some earlier authors as a part of *Bimastos parvus*, is now (e.g. Easton, 1983; Csuzdi & Zicsi, 2003: 132) included in the synonymy of *Dendrodrilus rubidus*; while *Eisenia*

veneta zebra Michaelsen, 1903 is put under *Dendrobaena veneta*. Friend's *hibernica* is in synonymy of *Dendrobaena hortensis*. It was further deduced by Easton (1983) that *Murchieona minuscula* (Rosa, 1906) takes priority over what some authors persist in calling *Allolobophora* or even *Aporrectodea muldali* (Omodeo, 1956); however, these two taxa were again separated by Zicsi & Csuzdi (1999 - see Csuzdi, 2002: 108, fig. 2). Levinson's *Lumbricus eiseni* continues its generic hop-scotch, back and forth from its starting place, e.g. it was errected type-species of *Allolobophoridella* Mršić, 1990, and although this author later added *Bimastos parvus*, he also admitted (Mršić, 1991) that his genus may be a synonym of *Bimastos*. After a fleeting inclusion in *Eophila*, Savigny's *icterica* is now also included in *Aporrectodea* cf. its replacement in *Eophila* herein.

The name *Eisenia fetida* was latinized to *Lumbricus foetidus* by Dugès (1837: 21), to *Allolobophora foetida* by Eisen (1874: 50), to *Allolobophora* (*Notogama*) *foetida* by Rosa (1893: 424) and to *Eisenia foetida* by Michaelsen (1900: 475) who also changed genus *Bimastos* to "*Bimastus*" and *Octolasion* to "*Octolasium*". Such changes are unjustified emendations under the articles of the ICZN and the original spellings are now restored (e.g., by Stöp-Bowitz, 1969: 212; Easton, 1981; 1983; Sims, 1983; Sims & Gerard, 1985; 1999). Controversy over priority of generic name *Octolasion* notwithstanding, Sims (1983: 470) advocated retaining it – see Sims (1984), ICZN (1986) and Stöp-Bowitz (1969: 177) saying: "*Thus reappear the ancient forms* Octolasion *(for* Octolasium*),* Bimastos *(for* Bimastus*) and* Eisenia fetida *(for* E. foetida*)*".

Recent extensive revisions by Blakemore (2004a, 2006, 2007, 2008) accepted most placements of species names following Easton (1983) – this despite Sims & Gerard (1985; 1999) appearing to have ignored many of Easton's changes, cf. Sims' (1983) endorsement – or following Csuzdi & Zicsi (2003). Much of the difficulty may result from the simplification that Csuzdi & Zicsi (2003: 31) summarize as: "*The structure of the excretory system is the most widely used character to draw evolutionary conclusion of [Lumbricidae] earthworm taxa*". Why this is unreliable, in my view, is that the shape of the nephridial bladders – key to generic diagnosis under some systems – may vary greatly from segment to segment within the same specimen of some taxa as shown by many examples in Qiu & Bouché (1998), in Csuzdi & Zicsi (2003: 109, fig. 6.18.1) and pers. obs.. Thus, as with the Megascolecidae, a pragmatic solution may lie in use of more reliable reproductive and somatic characters less influenced by the environment through time, or replaced with recourse to molecular means, as noted in the next section:

Note on Savigny's early lumbricid types as a basis for DNA resolution

Recently, preliminary attempts to breach taxonomic impasses have used molecular (DNA/RNA) methods, as for *A. caliginosa* and *E. fetida* species-complexes noted below. However, full resolution strictly requires comparison with the original type, where they still exist, or with a neotype (see ICZN, 1999: Art. 75). In May 1969, Stöp-Bowitz (1969: 172) had the opportunity to examine Savigny's types in Paris; he said:-

"*Most of the original material of Savigny still exists in the Muséum national d'Histoire Naturelle à Paris, and has been revised and redescribed by A. Tétry (1937a,b, 1938). This applies to the following species,* Eiseniella tetraedra, Allolobophora rosea, A. caliginosa *(only for the synonymic* Enterion carneum*),* A. chlorotica, Octolasion cyaneum, Eisenia fetida, Dendrobaena octaedra, D. rubida, Lumbricus castaneus, L. festivus *(and further to his* Enterion terrestre = Allolobophora longa, *and* E. herculeum = Lumbricus terrestris)." [Tétry was a female French worker active in the 1930-1940s]. Cf. Gates' notes on the *O. tyrtaeum* type below and Gates (1972: 83) doubting Cain's (1955: 491) act of selecting a lectotype for *caliginosa* from Savigny's *carneum* syntypes. Neotype for *L. terrestris* in British Museum – BMNH 1973:1:1 –is yet available for analysis and possible DNA testing (pers. obs. Blakemore, 2013 but also see Sims, 1973; 1983 and cf. James *et al.*, 2010 for false erection of a replacement neotype).

Key to Peregrine Lumbricid Genera cf. Table 5 below. Keys to species follow - jump.
(Derived from Gates, 1972; Sims & Gerard, 1985, 1999; and other sources).
This key's many anomalies are only an approximate guide (cf. Perel's 1996 key below)!

1. Nephridial vesicles absent (mostly!) ..... *Helodrilus*
   Nephridial vesicles present 2
2. Intra-or extramural calciferous glands present, rather than sacs 3
   Extramural or distended calciferous sacs/diverticula present 4
3. Setae closely paired; nephropores alternating irregularly ..... *Eisenia*
   Setae not closely paired; nephropores often single lateral rows ... *Dendrobaena*
4. Calciferous sacs with two chambers opening vertically through a U-shaped orifice into the oesophagus in segment 10 ..... *Murchieona*
   Calciferous sacs not so arranged 5
5. Calciferous sacs first open in 10 (at least?) 6
   Calciferous sacs first open just in front of 10/11 9
6. Nephridal vesicles ocarina-shaped possibly exit to single lateral rows 7

Nephridal vesicles J- or U-shaped to nephropores alternating irregularly … 8

7. Spermathecae two pairs in 9/10/11 ..... *Octolasion*
   Spermathecae 5-9 pairs ..... *Octodrilus*
8. Pigment, when present, not red ……..... *Aporrectodea*
   Pigment red …….....……. *Bimastos*
9. Nephridial vesicles sausage-shaped ……..... 10
   Nephridial vesicles J- or U-shaped ……..... 11
10. Male pores on 15, extending into 14 and 16; pigment red or dark… *Satchellius*
    Male pores on 13 (rarely 11 or 15); not usually red; gizzard in segment 17 only (as found in some other taxa also) (female pores just median to a) … *Eiseniella*
11. Prostomium epilobous ……..... *Allolobophora* [cf. *Eophila*]
    Prostomium tanylobous …….....…. *Lumbricus*

Cf. Key to Lumbricidae Genera (with those occurring in the USSR taken as examples) modified from Perel (1976: 641 – pdf courtesy of Cs. Csuzdi)

1. Nephridial bladders absent. Setae closely paired. No pigment. Clitellum ends <33 – *Helodrilus* Hoffmeister

or 2. Nephridial bladders present – 3.

3. Nephridial bladders in anterior segments J- or U-shaped. In following segments before 13-16 they can be S-shaped or boat-hook-shaped or ocarina-shaped*, fork-like or biramous – 14.

or 4. The curved part of the bladder is directed cephalad – 7.

5. Setae closely paired. Pigment brown or greenish-brown or absent (seldom red). Often more than two pairs of seminal receptacles (=spermathecae) or sometimes absent – *Allolobophora* Eisen (mostly large or medium sized species)

or 6. Setae widely paired. Pigmentation purple. Two pairs of seminal receptacles (=spermathecae) in 9/10/11 or they are absent – *Dendrodrilus* Omodeo

7. The curved part of the nephridial bladder is directed caudally, sometimes bladders ocarina-shaped* or bilobous – 8 (she mistakes this as “4” in an endless loop!).

8. Setae weakly paired. Nephiridial bladders (except some anterior ones) bilobous or ocarina-shaped* - 11.

9. Nephridial bladders bilobous*. Two pairs of spermathecae. – *Kritodrilus* Bouche (Small worms)

or 10. Nephridial bladders ocarina-shaped*. Pigmentation present or absent. Often

more than two pairs of spermathecae. Tubercula pubertates the whole length of clitellum or longer. – *Octolasion* Oerley (Medium to large worms)

11. Setae closely paired. Nephridial bladders from 15 often S-shaped – 12.

12. Seminal capsules absent (?). Epilobic. Pigment brown or absent – *Aporrectodea*

or 13. Testes & funnels in seminal capsules (aha!). Tanylobic. Purple – *Lumbricus*

14. Nephridial bladders in the anterior sac-like or sausage-like, from 15 they may be biscuit-shaped or seldomly J-shaped. [She provides no lead from this couplet].

15. Setae closely paired. Spermathecae open above the line of setae usually or sometimes absent – 18.

16. Gizzard in two or more segments. Calciferous glands never diverticulate in 10. Male pores on 15. Nephridial bladders sausage-shaped or sac-like – *Eisenia*

or 17. Gizzrd occupies only one segment. Calciferous glands with well developed diverticula in 10. Male pores on 13, 14 or 15. Nephridial bladders sausage-shaped – *Eiseniella*

18. Setae widely paired. Spermathecae open in D or dorsally (except *D. schmidti*) – *Dendrobaena*

* Perel confuses “ocarina”-shaped nephridial bladders with bilobed, just as Csuzdi does.

Map of Lumbricid distributions related to glaciations (from Michaelsen, 1903) [www.archive.org/stream/diegeographische00mich#page/n213/mode/2up].

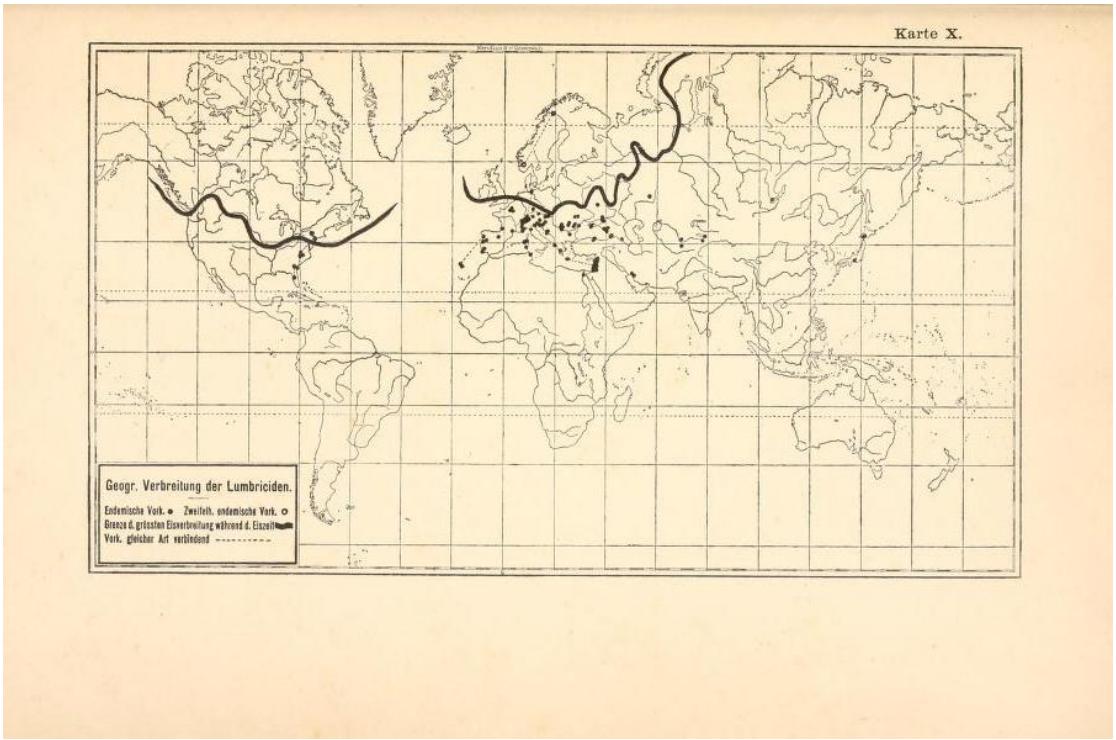


Table 5. Characters of common Lumbricidae genera [from Csuzdi & Zicsi (2003) vs. Sims & Gerard (1985; 1999) (**bolded** where they differ due partly to transfer of species), with additional notes from Stöp-Bowitz (1969) and Gates (1972). The present resolution seeks compromise between inherited conflicts & need to maintain convention - even if non-type speculation, versus ideal nomenclatural definition based on type of each genus' type-species].

Genus	**Setae pairing**	**Seminal vesicles**	**Nephridial bladder**	**Calciferous glands**	**Pigment**	**Other**
Allolobophora /Eophila	Close	9-12 or 9,11-12	(**U- or**) J-shaped with forward oriented ental part	Diverticula in 10 (10 or 11 in *Eodrilus*)	Not red	Muscle fasciculate (or intermediary); spermathecal pores in *c* (**or *cd*?**) lines
Aporrectodea	Close	9-12 or 9,11-12 (rarely 11,12)	U-shaped (**or J-shaped with backward oriented ental part**)	Diverticula in 10	Not red	Muscle pinnate; spermathecal pores in *cd* lines
Allolobophoridella	Close	11-12	U-shaped with forward oriented ental part	Diverticula in 10-12	Red	Tanylobous
Bimastos	Close	11-12	U-shaped (J-shaped too?)	Diverticula open in 10	Red	Epilobous; (gizzard double but in one segment)
Dendrobaena	Wide	9-12 or 9,11-12 (rarely 11,12)	**Ocarina**, sausage or biscuit-shaped (or J-shaped)	Diverticula (**or sacless**) in some or all of 10-13	Red (**or lacking**)	Muscle pinnate **or** fasciculate
Dendrodrilus	Not close	9,11,12 (rarely 11,12)	U- shaped	Diverticula in 10 (**open in 10/11**)	Red	Muscle pinnate
Eisenia	Close	9-12 or 11,12	Simple sausage-shaped	Diverticula in 11-12 or 11 or 12 (**or sacless opens in 11**)	Red (**or lacking**)	Muscle pinnate or fasciculate
Eiseniella	Close	Four (or three) pairs, 9-12	Simple saccular or shortly sausage-shaped	Diverticula in 10 (**open in 10/11**)	Not red, lacking	Gizzard in 17 only (not 17-18). Male pores often on 13.
Eisenoides	Close	9(10)11,12	Proclinate U-shaped	11 and 12	Varies-red or green	Body square (as also in *E. koreana*, etc)
Helodrilus	Close	9-12; (9),11-12	Lacking	Diverticula (**or sacless**) in 10	Lacking	Large male pores
Lumbricus	Close	9-12	J-shaped	Diverticula in 10	Reddish	Tanylobous
Murchieona	Close	-	Present	U-shaped in 10	Lacking	
Octolasion	Close, wider in tail	9-12	**Ocarina** or hook-shaped	Diverticula in 10, glands in 10-12	Lacking (rarely dark)	
Octodrilus	Wide	9-12;9-10,12 or 10,12	Hook-shaped (or ocarina?)	Diverticula in 10, glands in 10-12	Brown or red	
Satchellius	Wide	9-12	Sausage-shaped	Sacs in 10	Red	

Of the ca. 670 valid Lumbricidae, only about 50 are cosmopolitan species (Blakemore, 2006, 2007, 2008, 2010). About forty-four lumbricids, several native, are known from North America (Schwert, 1990; McKey-Fender *et al.*, 1994; Blakemore, 2007, 2008 and in press), up to 30 lumbricids have been recorded from the British Isles (Gerard, 1964; Cotton, 1978; Sims & Gerard, 1985), and 25 from Australia/Tasmania/New Zealand (Blakemore, 1999, 2000, 2001, 2002). The following common peregrines, as listed by Gates (1972: 62, tab. 1), were intercepted by the Bureau of Plant Quarantine in imports to the USA over a 15 year period:- *Allolobophora chlorotica*; *Aporrectodea longa*; *Ap. rosea*; *Ap. trapezoides*; *Ap. tuberculata*, *Ap. turgida* [= *Ap. caliginosa*]; *Bimastos parvus* [although thought a native North American]; *Dendrobaena octaedra*; *Dendrodrilus rubidus*; *Eisenia fetida*; *Eisenia rosea*, *Eiseniella tetraedra*; *Lumbricus castaneus*; *L. eiseni* [= *Allolobophoridella*]; *L. terrestris*; *Octolasion cyaneum* and *O. lacteum* [?= *O. tyrtaeum*] plus an additional 212 unidentified lumbricids. Other families amongst the 3,430 specimens quarantined were partly listed elsewhere, e.g. Gates (1982: end of page 15) says quarantine records were kept for 32 years.

Tables are presented below, the first is based on Stöp-Bowitz (1969: Tab. IV, p. 260) showing distribution of some European and North American species (with taxonomy updated but not the records that are comparable with those from Blakemore, 2005, 2007 and Table 8); the second is a Table of Norwegian Lumbricidae from Stöp-Bowitz (1969: 258, Tab. III) that shows their wider distribution, as known up to that time.

Uws Scwarz (1995) provides some online information, summarized here.

Keys to genera/species are provided after these tables below.

Distribution of most cosmopolitan lumbricids are shown in an Appendix (Table 8) cf. Michaeslen's chart and data from more than a Century ago in 1903 (Ref).

Table of Scandinavian Lumbricidae from adjacent countries and North America

[After Stöp-Bowitz (1969: Tab. IV, p. 260) with taxonomy updated, but not the records]. N- Norway, S - Sweden, F- Finland, R- Russia, D- Denmark, G- Germany, B- Britain, I- Iceland, G- Greenland, E- Eastern North America. Key: x - present, - - absent (or unknown).

***Species*/Region**	**N**	**S**	**F**	**R**	**D**	**G**	**B**	**I**	**G**	**E**
Eiseniella t. tetraedra	x	x	x	x	x	x	x	x	-	x
E. t. hercynia	-	x	-	-	x	x	x	-	-	x
E. t. cerni	x	-	-	-	-	-	-	-	-	-
Aporrectodea rosea	x	x	x	x	x	x	x	x	-	x
Ap. caliginosa	x	x	x	x	x	x	x	x	-	x
Ap. nocturna	-	-	-	-	-	-	x	-	-	-
Ap. longa	x	x	x	x	x	x	x	-	-	x
Ap. limicola	-	-	-	-	-	x	-	-	-	x
Allolobophora chlorotica	x	x	x	-	x	x	x	-	?	x
Helodrilus oculatus	-	-	-	x	-	x	x	-	-	-
Octolasion cyaneum	x	x	x	-	x	x	x	x	-	x
Oc. lacteum	x	x	x	x	x	x	x	x	-	x
Eisenia fetida (inc. *fasciata*)	x	x	x	x	x	x	x	x	-	x
E. nordenskioldi	-	-	-	x	-	-	-	-	-	-
Al. eiseni	-	x	-	-	x	x	x	-	-	-
Bimastos parvus (inc. *beddardi*)	x	x	x	x	x	x	x	x	x	x
Dendrobaena octaedra	x	x	x	x	x	x	x	x	x	x
D. veneta	-	-	-	x	-	-	x	-	-	-
D. hortensis (inc *hibernica*)	x	x	-	x	-	x	x	-	-	x
Dendrodrilus rubidus	x	x	x	x	x	x	x	x	-	x
Du. subrubicundus	x	x	x	x	x	x	x	x	-	x
Du. tenuis	x	x	x	x	x	x	x	x	-	x
Du. norvegicus	x	x	-	-	-	-	-	-	x	?-
Satchellius mammalis	-	-	-	-	-	-	x	-	-	x
Lumbricus rubellus	x	x	x	x	x	x	x	x	?	x
L. castaneus	x	x	x	-	x	x	x	-	-	x
L. terrestris	x	x	x	x	x	x	x	x	-	x
L. festivus	x	x	-	-	x	x	x	-	-	x
***Species*/Region**	**N**	**S**	**F**	**R**	**D**	**G**	**B**	**I**	**G**	**E**

N- Norway, S - Sweden, F- Finland, R- Russia, D- Denmark, G- Germany, B- Britain, I- Iceland, G- Greenland, E- Eastern Nth America. Key: x, present; -, absent (or unknown). Cf. Table below of Norwegian Lumbricidae from Stöp-Bowitz (1969: 258, Tab. III).

Table III. Complete distribution of Norwegian Lumbricids

	Eiseniella tetraëdra	*Allolobophora rosea*	*Allolobophora caliginosa*	*Allolobophora longa*	*Allolobophora chlorotica*	*Octolasion cyaneum*	*Octolasion lacteum*	*Eisenia fetida*	*Dendrobaena octaëdra*	*Dendrobaena hortensis*	*Dendrobaena rubida*	*Dendrobaena subrubicunda*	*Dendrobaena tenuis*	*Dendrobaena norvegica*	*Lumbricus rubellus*	*Lumbricus castaneus*	*Lumbricus terrestris*	*Lumbricus festivus*
Western North America	x	x	x	–	x	–	x	x	x	x	–	x	x	–	x	–	x	–
Eastern U.S.A.	x	x	x	x	x	x	x	x	x	x	x	x	x	–	x	x	x	x
Bermudas	–	–	x	–	x	–	–	x	–	–	–	–	–	–	–	x	–	–
Eastern Canada	x	x	x	x	x	–	–	–	x	–	–	x	x	–	x	x	x	x
New Foundland	–	–	x	–	–	–	–	–	x	–	–	x	–	–	x	–	x	–
Greenland	–	–	–	–	?	–	–	–	x	–	–	–	–	x	?	–	–	–
Iceland	x	x	x	–	–	x	–	?	x	–	x	x	?	–	x	–	x	–
Faeroes	x	–	x	–	–	x	–	x	x	–	?	–	–	–	x	x	–	–
Norway	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sweden	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Finland	x	x	x	x	x	x	x	x	x	–	x	x	?	?	x	x	x	–
Novaya Zemlya	–	–	–	–	–	–	–	–	x	–	–	–	–	–	–	–	–	–
Northern Russia	x	x	x	x	–	–	x	x	x	x	–	x	x	–	x	–	x	–
British Isles	x	x	x	x	x	x	x	x	x	x	x	x	x	–	x	x	x	x
Denmark	x	x	x	x	x	x	x	x	x	–	x	x	x	–	x	x	x	x
Central Europe	x	x	x	x	x	x	x	x	x	x	x	x	x	–	x	x	x	x
Southern Russia	–	x	x	x	–	–	x	x	–	x	–	–	x	–	–	–	–	–
Iberian Peninsula	x	–	x	–	x	–	x	x	x	x	–	–	–	–	–	–	–	–
Mediterranean isles	x	x	x	–	–	–	x	x	x	–	?	–	–	–	x	x	–	–
Italian Peninsula	x	x	x	x	x	x	x	x	–	x	–	–	x	–	x	x	–	–
Balkan Peninsula	x	x	x	–	x	–	x	–	x	x	?	?	x	–	x	–	x	–
Azores	x	x	x	–	x	–	x	x	–	–	–	x	x	–	–	–	x	–
Madeira	–	–	x	–	x	–	x	x	x	–	–	–	–	–	–	–	x	–
Canary Isles	x	x	x	–	x	–	x	x	–	–	–	–	–	–	x	–	–	–
Northern Africa	–	x	x	–	–	–	x	–	–	–	–	x	–	–	–	–	–	–
Israel-Jordan-Syria-Libanon	x	x	x	–	x	–	–	–	–	–	–	–	–	–	–	–	–	–
Transcaucasia	x	x	x	–	–	–	–	x	x	–	–	–	x	–	x	–	–	–
Persia	x	–	x	–	–	–	x	–	–	–	–	–	–	–	–	–	–	–
West Turkestan	x	x	x	–	–	–	x	x	–	–	–	–	–	–	x	–	–	–
Western Siberia	–	x	–	–	–	–	–	–	x	–	–	x	–	–	–	–	–	–
Northern & Eastern Siberia	–	–	–	–	–	–	–	x	x	–	x	–	–	–	x	?	?	–
Manchuria	–	–	–	–	–	–	?	–	–	–	–	–	–	–	–	–	–	–
China	–	–	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Japan	–	?	x	–	–	–	–	x	x	–	–	–	x	–	–	–	–	–
Mexico	–	x	x	–	x	–	x	x	x	–	–	–	x	–	–	–	x	–
Central America	–	–	–	–	x	–	–	x	–	–	–	–	x	–	–	–	–	–
South America	x	x	x	–	x	x	x	x	x	x	x	x	x	–	–	–	–	–
Tierra del Fuego	–	–	–	–	–	–	–	–	–	–	–	x	x	–	–	–	–	–
Falkland Isles	–	–	–	–	–	–	–	–	–	–	–	x	–	–	–	–	x	–
Tristan da Cunha	–	–	–	–	–	–	–	–	–	–	–	–	–	–	x	–	–	–
St. Helena	–	–	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
South Africa	x	–	x	–	–	–	–	x	–	x	–	–	–	–	–	–	–	–
India	x	x	x	–	–	x	x	x	x	–	x	x	x	–	x	–	x	–
Nicobar Isles	–	–	–	–	–	–	–	x	–	–	–	–	–	–	x	–	–	–
Australia	x	–	x	–	–	?	?	x	–	–	x	x	–	–	–	–	–	?
New Zealand	x	x	x	–	–	–	–	x	–	–	–	–	x	–	x	–	?	–
Chatham Isles	–	–	–	–	–	–	–	–	–	–	–	–	–	–	x	–	–	–
Hawaii	–	–	x	–	–	–	–	x	?	–	–	–	x	–	–	–	–	–

Key to Common Peregrine Lumbricidae

(SP = spermathecal pores; TP = tubercula pubertatis – the glandular ridges or papillae)*.

[Originally compilied from various sources including personal observations].

1. Male pores usually on 11 or 13 (rarely 15), clitellum annular but weak ventrally; tail quadrangular (as in *B. parvus*, *D. octaedra* and *E. balatonica*); female pores medial to setae a; habitat (semi-)aquatic ..... *Eiseniella tetraedra* species-group *s. lato*

Male pores on 15; clitellum saddle-shaped .....… 2

2. Athecal (i.e., spermathecae absent) .....…… 3

Thecal (i.e., spermathecae present, ventral or dorsal) .....… 7

3. Pigment redish, at least in anterior, or dark grey/brown .....…….. 4

Unpig./pinkish ... morphs of *Aporrectodea rosea* or *Murchieona minuscula*

4. Setae not or not all widely paired, TP absent 5

Setae widely paired .....…. *Dendrobaena* or *Dendrodrilus* (10 or 25)

5. Clitellum 24-32,33; prostomium tanylobous ..... *Allolobophoridella eiseni*

Clitellum usually 22,23,24-30; prostomium epilobous ... *Bimastos parvus* (formerly *Allolobophora parva*); see separate *Bimastos* spp. key

6. Nephridial bladders absent; (clitellum 22-32) … *Helodrilus oculatus* (cf. *He. hachiojii*)

Nephridial bladders present ……... 7

7. Spermathecal pores near mid-dorsal line (above d lines) .....……. 8

Spermathecal pores in region of c, cd or d lines 11

8. Calciferous sacs, present in 10 ..... morphs of *Aporrectodea rosea*

Calciferous sacs, lacking in 10 9

9. Setae closely paired, TP 28-30 (glands lacking) ..... *Eisenia fetida/*(*E. andrei*)

Square, setae close paired, TP 26,27-28,29 ... *Eisenoides carolinensis/lonnbergi**

Setae widely paired, TP 30-32 (+ glands) …….. 10

10. Size generally <50 mm with uniform red colour dorsally, tubercules on 29,30-31,32 and calciferous lamellae in 11-13 …..... *Dendrobaena hortensis*

Size generally >50 mm with striped red/yellow bands laterally, tubercules mostly on 30 & 31 and calciferous lamellae in 10-11 .... *Dendrobaena veneta*

11. Setal couples closely paired.....… 12

Setae widely paired or separate.....…..... 23

12. Tanylobous; pigmented red/brown; seminal vesicles three pairs ……. 13

Epilobous; not red; seminal vesicles absent, or two to four pairs ….... 16

13. Clitellum, begins behind 30 .....…….....……..……..... 14

Clitellum, begins on or in front of 30 .....……..... 15

14. Clitellum ½33,34-40; TP 35-38, narrow bands……. *Lumbricus festivus*

Clitellum ½32,33-37,½38; TP 34-37, papillate on 34 and 36… *L. friendi*

Clitellum, 32-37,38; TP 33-36, ridge-like…….. *Lumbricus terrestris*

15. Clitellum flared, 26,27-31,32; TP 27,28-31, broad bands .... *Lumbricus rubellus*

Clitellum unflared, 27,28-33; TP 29-32; white pads (9),10,(11) … *L. castaneus*

16. Clitellum from 33,34-42,43; TP from 34,35-41,42,43 …. *Aporrectodea icterica*

Clitellum in range between 48-62 ... *Eophila molleri/moebii* species-complex

Clitellum and TP not so posteriorly placed …….. 17

17. Sexthecal, spermathecal pores (SP) at 8/9/10/11..... *Allolobophora chlorotica*

Quadrithecal, SP at 9/10/11 and TP suckers in 31, 33 & 35… *Al. chlorotica*

Quadrithecal, SP at 9/10/11; TP not 31, 33 & 35…….……... 18

18. Mostly unpigmented .....…….…….…. 19

Darkly pigmented .....……..…..... 31

19. First dorsal pore in (or near) 4/5 …...…….…….…….... 20

First dorsal pore after 6/7 …...……..……. 22

20. Clitellum 23,24-31; TP distinct papillae in 27 & 29 … *Eisenia japonica*
    Clitellum 25,26-32,33; TP 28,29-31,32 ….. *Allolobophora cupulifera*
    Clitellum 28,29-35 …….. 21

21. TP 31,32-34,35 …….. *Aporrectodea jassyensis*
    TP two distinct papillae paired in 31 and 33 ……. *Aporrectodea georgii*

22. TP pronounced on 31-33 or 31 & 33 ….. *Aporrectodea caliginosa* species-complex
    TP absent or not so pronounced …… *Murchieona minuscula*

23. Spermathecae fewer than five pairs 24
    Spermathecae more numerous (e.g. five to eight pairs from 6/7); TP as long as length of clitellum, from 30 – 37 (at least) ……..……...…. 30

24. Pigment red or reddish 25
    Unpigmented or without red pigment 28

25. Sexathecal, spermathecal pores at 9/10/11/12 ……..…….. 26
    Quadrithecal, spermathecal pores at 9/10/11 …….…..... 27

26. Clitellum 28,29-33,34; TP 31-33 …….. *Dendrobaena octaedra*
    Clitellum 33-37; TP absent or weak in 35-37 … *Dendrobaena pygmaea*

27. Clitellum 28,29-34; TP 30-32, ½33 ....……. *Dendrobaena attemsi*
    Clitellum before 29 but not after 33 ..... morphs of *Dendrodrilus rubidus* [see separate tables and keys]
    Clitellum 31-36, TP 31-34 …… *Satchellius mammalis*

28. Clitellum before segment 40 29
    Clitellum in range between 48-62 ... *Eophila molleri/moebii* species-complex

29. Clitellum, 29-34,35; TP, 29,30-33,34 .....…..... *Octolasion cyaneum*
    Clitellum, 30-35; TP, 31-34 .....…….……. *Octolasion lacteum*

Clitellum, 30-35; TP, 30-35 .....……..…… *Octolasion tyrtaeum*

30. Clitellum 28,29-37; TP 28,29-38,39; SP 6/7-12/13 …..... *Octodrilus complanatus*
Clitellum 29,30-37; TP 29,30-37,38; SP 6/7-10/11 ... *Octodrilus transpadanus*
Clitellum 29,30-37,38; TP 29,30-38: SP 6/7-10/11 ..... *Octodrilus gradinescui*

31. TP, 32-34; 145-220 segments (prostomium schizolobous) .. *Aporrectodea longa*
TP, 31-33; <170 segments (epilobous) ..... *Ap. trapezoides* species-group

*Abbreviations: SP = spermathecal pores; TP = tubercula pubertatis.

*Genus *Eisenoides* Gates, 1969 spp. from USA has epilobous prostomium; closely paired setae; SP dorsally; clitellum 23,24,25-29,30, TP 26,27-28,29; *Es. carolinensis* was introduced from USA to Germany and is remarkable similar to *Ei. koreana*.

Note: *Kenleenus armadas* Blakemore, 2012 was recently reported (but misidentified as *Prosellodrilus amplisetosus*) from Ireland by Keith & Schmidt (2012).

For lumbricids, the use of more than one key is advisable to identify a specimen (e.g. Smith, 1917: 159; Gates, 1972 vs. Schwert in Dindal, 1990 vs. Sims & Gerard, 1999), the name can then be compared with synonymies and the identity checked against the descriptions below. Specific identification is rarely possible without at least cursory information on internal anatomy. But, since some classifications are contradictory and based on obscure somatic features or on characters that are highly variable intraspecifically, also because most of the peregrine lumbricids recorded from around the world are parthenogenic morphs, only brief diagnoses and synonymies are possible for some taxa that require a great deal more treatment for full resolution. Examples of the residual problems of generic definition are given in the Lumbricidae introduction above.

The field guides to living specimens and key to some immature lumbricids presented below (modified from Stöp-Bowitz, 1969) demonstrates difficulty of superficial identification. Characteristic behaviours and/or typical habitats may help (e.g. as in studies by Blakemore, 1981; 1994). Genomic barcoding solution is still in its infancy, but realization of this fledgling technology will forever remain invalid without testing of tissue (e.g. from reiterative 'tail' segments) from primary types, regardless whether of recent or historical species (plus all their synonyms!!). Vouchers are irrelevant despite being epoused by genomic 'gel jockeys' who often behave like irresponsible 'taxonomic tourists'! [See note under Vandalism above (and cf. Ref.)].

Field guides to living specimens of some lumbricids from Northern Europe [after Stop-Bowitz (1969) (but lacking distinctive behaviours keyed by Blakemore, 1981)].

I. Without dark reddish pigment

Body quadrangular, sienna-brown colour, small size, aquatic – *Eiseniella tetraedra*

Clitellum prominent, dorsal pores (DP) conspicuous, anterior blunt, pale pinkish red, small to medium size, comes to surface when soil vibrated – *Aporrectodea rosea*

Anterior segments long and tapering, tubercula pubertatis forming papillae on each side of ventrum on clitellum, greyish-pink, medium size – *Apporectodea caliginosa*

Tubercula pubertatis (TP) forming 3 pairs of suckers on clitellum, green or pink forms, medium size, often in rich organic soils – *Allolobophora chlorotica*

Prostomium schizolobous, greyish-brown anterior, large size – *Ap. longa*

Flaccid, bluish with yellow posterior, medium size – *Octolasion cyaneum*

Flaccid, whitish or brownish, seae closely paired anteriorly – *O. lacteum*

II. With dark reddish pigment

A. Prostomium not tanylobous

Intersegments yellow throughout, small size, in composts – *Eisenia fetida*

Tip of tail yellow, small size – *Dendrodrilus subrubicunda*

Setae distant, dd> other ratios – *D. rubidus*

Body octagonal, setae equidistant, small size – *Dendrobaena octaedra*

Setae widely paired, segments 9-10 yellow laterally (cf. *D. attemsi*), small – *D. hortensis*

B. Prostomium tabylobous

Large size, tail spade-shape – *Lumbricus terrestris*

Male pores on papillae, dark brown, medium size – *L. festivus*

Male pores without papillae, red, mid size – *L. rubellus*

Male pores without papillae, brown, small – *L. castaneus*

Field guide to immature Northern European lumbricids lacking clitella and TPs

I. Without dark pigment

A. Setae closely paired

1. Body quadrangular – *Eiseniella tetraedra*

2. Body cylindrical or flattened

a. Prostomium ‘schizolobous’ – *A. longa*

b. Prostomium epilobous

Dorsal pores cospicuous, anterior blunt – *A. rosea*

Dorsal pores not conspicuous, anterior tapers

Anterior 9 segments elongate – *A. caliginosa*

Anterior segment not longer – *A. chlorotica*

B. Setae anteriorly closely paired, posteriorly widely paired

1. Setae delicate, tip of tail yellow – *O. cyaneaum*

2. Setae conspicuous, tail not yellow – *O. lacteum*

II. With dark red pigment.

A. Prostomium epilobous.

1. Setae closely paired, intersegmental furrows yellow – *E. fetida*

2. Setae not closely paired

a. Setae equidistant, body octagonal – *D. octaedra*

b. Setae distant, dd> other ratios

3 pairs of seminal vesicles, 2 pairs of spermathecae

No yellow furrows, ventral setae closely paired – *D. rubida*

Yellow furrows in posterior – *D. subrubicundus*

2 pairs of seminal vesicles, 0-2 pairs spermathecae

No spermathecae – *D. tenuis*

Spermathecae present – *D. norvegicus*

3. Setae widely paired, bc = 2ab – *D. hortensis*

B. Prostomium tanylobous

1. Setae in anterior and posterior more widely paired, tail spade-shaped – *L. terrestris*

2. Setae not widely paired

a. Setal line not diverging anteriorly, abdomen dark – *L. castaneus*

b. Setae ab diverging in front of segment 15

Setae diverge in 5-10, abdomen dark – *L. festivus*

Setae diverge in 2-15, abdomen pale – *L. rubellus*

Following generic and species accounts of Lumbricidae are arranged alphabetically for convenience. Remember to cross check all identifications of lumbricids that, despite being diverse, are often similar superficially.

Genus ***Allolobophora*** Eisen, 1874

Allolobophora Eisen, 1874: 46 [sometimes dated "*1873*"]; Michaelsen, 1900: 480.

Type-species: *Lumbricus riparius* Hoffmeister, 1843 (= *A. chlorotica*). [Type *riparius* was listed in Reynolds & Cook (1976: 47), possibly in error; however, Csuzdi & Zicsi (2003: 48) say that *A. chlorotica* was type by subsequent designation (Omodeo, 1956).

Diagnosis: Setae closely paired. Prostomium epilobous. Pigment, if present, not red. Calciferous sacs discharging posteriorly and ventrally into oesophagus of segment 10 just in front of septum 10/11. Calciferous lamellae continue along lateral walls of sacs to anterior. Nephridial vesicles J-shaped (or U-shaped in *chlorotica*) ducting to bodywall near setal b lines. Nephropores alternate irregularly on each side anywhere above setal lines b (and d). Longitudinal mucle layer of fasciculated (or intermediary) type.

Distribution: Europe and Asia-minor. About 64 included taxa listed by Easton (1983) are now refined to about 50 (Blakemore, 2007); the type-species (and sub-species?) widely distributed Cosmopolitan and there is evidence of transportation of two other taxa in Europe (Csuzdi & Zicsi, 2003). Semi-aquatic ***Allolobophora leoni*** Michaelsen, 1891: 15 has Trans-Aegean distribution from Italy to Ukraine and occurs by introduction on the eastern shore of the Black Sea (Csuzdi & Zicsi, fig. 6.5.2); ***Allolobophora nematogena*** Rosa, 1903: 11 (syn. *meledaensis* Michaelsen, 1908; ?*bellicosa* Ude, 1922; *dudichiana* Zicsi, 1966) is from Hungary, Bosnia, Croatia and Italy is probably introduced into Turkey and Cyprus (Csuzdi & Zicsi, 2003; Pavlicek & Csuzdi, 2006). ***Allolobophora cupulifera*** Tétry, 1937 was recently reported (as an introduction) to Ireland and it is sometimes listed as *Aporrectodea cupulifera* (Tétry, 1937), perhaps following its rescue from *Koinodrilus*; it is briefly described after *A. chlorotica* below.

Notes: The supposedly definitive J-shaped nephridial vesicles are almost U-shaped in the type-species (Gates, 1972; Csuzdi & Zicsi, 2003). Other differences conflicting with Sims & Gerard's *Allolobophora* diagnosis, after Easton's (1983) transfer of species, are noted in brackets in the diagnosis above (and in Table 5) cf. Csuzdi & Zicsi (2003).

For previous "***Allolobophora molleri/moebii***" spp-complex - see ***Eophila*** below.

Key to transported *Allolobophora* species

Clitellum 25,26-32, tubercules in 28,29-31 (or just 28 and 30) .... *Al. cupulifera*

Clitellum 25,26-34, TP suckers 30,32 …… *Al. leoni*

Clitellum 25,26-33,34, suckers 29,30-32,33 ... *Al. nematogena* (in *Microeophila*?)

Clitellum 29-39, suckers in 31,33,35 (plus some variation) ….. *Al. chlorotica*

Allolobophora chlorotica chlorotica (Savigny, 1826)

Fig. 6.1. *Allolobophora chlorotica*, sketch of author's Tasmanian specimen: ventral view with three spermathecae, and dorsal view of prostomium.

Enterion chloroticum Savigny, 1826: 182/3. [Locality Paris. Types in Paris Museum]. The name in Latin indicates green colouration. On page 182 Savigny described his 6th "Tribu" and for species 14 on page 183 all that Savigny says, in its entirety, is: "*La ceinture, de neuf segmens, finit avec le trente-septieme du corps*."

Enterion virescens Savigny, 1826: 182/3. [Locality Paris. Types in Paris Museum]. The name "*virescens*" in Latin suggest "*tending to a green colour*" although it is sometimes claimed as a pink morph! All that Savigny says for species 15, in its entirety, is: "*La ceinture est comme dans la precedente, dont celle-ci differe principalement par la couleur, et n'est peut-etre qu'une variete*".

Lumbricus anatomicus Dugès, 1828: 289. [Types missing]. [Non *anatomicus* Hoffmeister, 1845 (= *A. rosea*)]; Johnston, 1865: 60. Name suggests a "*dissected structure*". Note: Qiu & Bouché, 1998: 190 attempted to reinstate this name.

Lumbricus riparius Hoffmeister, 1843: 189, fig. IV; 1845: 30. [From neighborhood of Berlin? Types ?] [Non Bretcher, 1910]. Latin name for "*frequenting riverbanks*".

Lumbricus communis luteus Hoffmeister, 1845: 29. [Non *Lumbricus luteus* Blanchard, 1849]. [From neighborhood of Berlin? Types missing?]. The name indicating either yellow or muddy coloured.

Lumbricus viridis Johnston, 1865: 60. [From Rhodam, Northumberland. Types?]. [Non *Nicodrilus longus ripicola* var. *viridis* Bouché, 1972: 325 – invalid varietal name (see *Ap. longa*)]. Its name indicates a greenish form of the worm.

Lumbricus riparius rufescens Eisen, 1871: 966. [Types?] (non Johnston, 1827: 327). Name means "*rufous*" or reddish.

Lumbricus riparius pallescens Eisen, 1871: 966. [Types?]. Name suggests "*inclining to paleness or pallor*".

Allolobophora neglecta Rosa, 1882: 170. [Types ?]. Neglected name?

Allolobophora cambrica Friend, 1892: 31. [Types missing]. [Also cited as *Allolobophora chlorotica* f. *cambrica* Friend, 1923: 40].

Allolobophora chlorotica var. *curiosa* + *chlorotica* var. *waldensis* + *chlorotica morgensis* + *nusbaumi* + *Cambria* (?laps. pro *cambrica*) Ribaucourt, 1896: 46, 47, 47, 84, 94. [Types?]. [Sometimes *waldensis* is retained, see Notes below, and sometimes *morgensis* is misspelt as "*morganensis*"].

Helodrilus (Allolobophora) chloroticus: Michaelsen, 1900: 486 [syn. *anatomicus*, *riparius*, *riparius pallescens*, *riparius rufescens*, *communis luteus*, *viridis*, *neglecta*, *cambrica*, *curiosa* + *waldensis* + *morgensis* + *cambria* (laps.)]; Smith, 1917: 167 (syn. *virescens, riparius*).

Octolasion hortensis Brescher, 1901: 221. [Types in Zurich]. [Non *hortensis* Michaelsen, 1890 (= *Dendrobaena hortensis*)]. Meaning "*of the garden*".

Allolobophora chlorotica: Tétry, 1937: 145; Omodeo, 1956: 180 (designation as type-species); Gerard, 1964: 30; Stöp-Bowitz, 1969: 201; Gates. 1972: 69, 1980: 177; Sims & Gerard, 1985, 1999: 50, figs. frontcover, 12 (?syn. *virescens*).

Allolobophora vardarensis Sapkarev, 1971: 157. [Types?]. (Syn. from Csuzdi & Zicsi, 2003).

Allolobophora chlorotica kosovensis Sapkarev, 1975: 43. [Type in author's collection]. [Syn. from Csuzdi & Zicsi, 2003 that they sometimes misdate as "Sapkarev, 1977"; non *Allolobophora kosowensis* Karaman, 1968].

Allolobophora chlorotica chlorotica: Easton, 1983: 475 (syn. *virescens*, *anatomicus*, *riparius*, *viridis*, *riparius rufescens* + *r. pallescens*, *neglecta*, *cambrica*, *chlorotica curiosa*, *hortensis* Brescher, 1901); Qiu & Bouché, 1998: 190 (including their attempt to reinstate *chlorotica anatomica*); Csuzdi & Zicsi, 2003: 50, fig. 3.8a (re-synonymize *chlorotica anatomica*); Blakemore, 2004, 2005, 2007.

?*Allolobophora* (*Allolobophora*) *chlorotica eutypica* Qiu & Bouché, 1998: 88, fig. 1, tab. 1. [From supposed type-locality of *A. chlorotica* proper in France (Paris?). Holotype and two paratypes given same CO-ECO numbers "*20/1614/1741*" and "*1614/1741*", respectively]. **Syn. nov?** [Morph with clitellum on 29,30-36 and merely lacking anterior pair of spermathecae, cf. *A. chlorotica postepheba*].

Taxonomic Notes: Easton (1983) and Csuzdi & Zicsi (2003) did not entirely accept all of the above synonymies: Easton listed three subspecies: ***A. chlorotica waldensis*** Ribaucourt, 1896: 47 (syn. *chlorotica morgensis* Ribaucourt, 1896: 47; *nusbaumi* Ribaucourt, 1896: 84) – with clitellum on 30-36 and spermathecae in 7/8/9/10/11; ***A. chlorotica postepheba*** Bouché, 1972 –with clitellum on 30-38 and suckers on 32, 34 and

36; and ***A. chlorotica kosovensis*** Sapkarev, 1975. Csuzdi & Zicsi (2003) considered the latter as a synonym of the nominal species with variable suckers as they found specimens with suckers in the normal location of 31,33,35 on one side and a continuous row in 31-35 on the other side. ***A. chlorotica eutypica*** Qiu & Bouché, 1998 apparently differs only by having clitellum in 29,30-36 and just two pairs of spermathecae in 9/10/11 [their Table 2 is quite wrong to state suckers are in "*31, 32, 35*" as these are clearly shown in their Fig. 1 to be in 31, **33**, 35 – i.e., the same as in *A. chlorotica* proper!]. All these sub-species probably yet require confirmation against types (and prior synonyms) of *A. chlorotica* proper (cf King *et al.*, 2008 who are ignorant of this).

Note that European *Al. smaragdina* Rosa, 1892 [sometimes placed in *Aporrectodea*] also has a deep green colouration like *Al. chlorotica*.

Distribution: All of Europe and Scandinavia; Russia; Mt Hermon, Syria; Lebanon; Israel (under *Platanus* tree – Csuzdi & Pavlicek, 2005: 88); Algeria; Iran (interception Gates, 1972: 70); Azores; Canaries; Madeira; St Helena; the Americas [e.g. Nova Scotia, New Brunswick, Quebec, N.Y., North Carolina, Vancouver Island, California, Mexico, Guatemala, Bermudas, Peru, Chile, Uruguay, Bolivia, Connecticut, District of Columbia, Indiana, Colorado, Ohio (etc. from Gates, 1942: 102; 1972: 70), Minnesota, and Missouri (Olsen, 1936)]; Greenland; Iceland; New Zealand; Australia - reported from Victoria (Tisdall, 1985); SA (J. Buckerfield pers. com.), and Tasmania (pers. obs. and new record from that State).

Locality: Tasmania – first records by R.J.B..

Habitat: Wet organic soils; sands to clays; moss; composts; banks of waterways; caves; mud and below waterlevel in roots of *Littorella* and *Phragmites* spp.; just below high-tide mark on sheashore (Bermuda).

Behaviour: Coils in spiral when alarmed or placed in preservative and exudes yellow coelomic fluid; facultative diapause reported.

Length: 30-80 mm. **Width:** 3-7 mm. **Segments:** 80-143.

Colour: Variable and dimorphic, either coloured black/dark-green/yellowish green or unpigmented pink; (juveniles also unpigmented). Possibly dependent on habitat and diet and also with intermediate and changeable colours (i.e. character perhaps not consistent).

Prostomium: Open epilobous.

First dorsal pore: 4/5 or 5/6.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired from 2; ventral setal couples in tumescences e.g. 9,10-11 and 27, 29, 32 also setae cd on 10;

(13:1.5:6:1:25:0.45).

Nephropores: Inconspicuous in alternating irregularly in and above b and d lines.

Clitellum: saddle-shaped, 28,29,30-37.

Male pores: Large equatorial slits in 15 in bc, almost lateral within pale highly tumid lips that extend into ½14-½16.

Female pores: Small slits lateral and/or above b setae on 14.

Spermathecal pores: 8/9/10/11 lateral in c or d lines (in 9/10/11 in *A. c. eutypica*).

Genital markings: Sucker-like discs paired lateral of ab in 31,33,35 (rarely displaced e.g. unilaterally in some or all of 30,31,32,33,34,35,36 on either side; Qiu & Bouche, 1998: 89; Csuzdi & Zicsi, 2003: 51).

Septa: 6/7-9/10 some thickening.

Nephridia: Holoic with J-shaped to almost U-shaped bladders (Gates, 1972).

Calciferous glands: As sacs in 10, digitiform to pyriform, opening in front of 10/11, lamellae continue to anterior ends of sacs internally.

Intestinal origin (typhlosole): 15; typlosole T-shaped from 21-23.

Gizzard: 17.

Nephridia: Holoic, bladders J-shaped or almost U-shaped (Gates).

Hearts: Last pair in 11.

Male organs: Holandric; seminal vesicles in 9-12.

Prostates: Absent.

Spermathecae: Three pairs in 9-11, ampulla elliptical, adiverticulate (2 pairs in *eutypica*).

Gut contents: ?

Notes: Spermatophores often on segments 26-39 (Sims & Gerard, 1999: 50); thus loss of non-functional spermathecae, as claimed in ***Al. chlorotica eutypica***, is not entirely unexpected and it probably does not merit separate sub-species status if it is merely a variational morph; similarly, ***A. chlorotica waldensis*** appears to have merely gained an extra pair of spermathecae (in how many specimens?).

Al. chlorotica has been identified as a food for British nestling wild birds (Ref.) and, along with *Ap. rosea*, as a host for *Pollenia rudis* parasitic dipterans (Web & Hutchings, 1916). It has been shown to contain "*protoporphyrin IX, coproporphyrin 111, and a 3-COOH porphyrin*" (Ref.) and the green phases get their colour from biliary pigment and it it is stated that "*colouration is unaffected by diet*" by Sims & Gerard (1999).

Al. chlorotica was dominant in gley soil and "*was found to be in diapause, i.e., curled up*" during flood and drought in Germany (Ref.).

The species *Allolobophora chlorotica* was also dominant and almost entirely accounted for the increased earthworm abundance in organic sections, including a 1,000 year old permanent pasture, of the Haughley Experiment in Suffolk (Blakemore, 2000). Thus it is considered a beneficial species implicated in stabilization of sustained soil habitats. In contrast, Friend (1911: 14) reported from Belfast that *A. chlorotica* was damaging to garden plants:

> "*"In answer to your request in the Irish Naturalist for injurious worms. I enclose a few specimens from my garden which are most destructive. They seem to live at the roots of the plants, and slowly eat all these away, until the plant is left sitting on the surface of the soil, and of course dies." The worms were immature specimens of* Aporrectodea (Allolobophora) chlorotica*, Savigny, and it will be news to very many people that the Green Worm is to be looked upon as a pest*."

Remarks (from Sims & Gerard, 1985; 1999): Obligatory biparental. The colour dimorphs are believed to be ecotypes: the coloured phase in pastures and waterways vs. the unpigmented phase in well-drained gardens and woodlands (e.g. Lowe & Butt, 2006). The situation is perhaps analagous to that pertaining to *Eisenia fetida* / *andrei*. However, further work is required to determine the relationships between morphs and, should they be restored to species level, the green morphs will continue to be known as *chlorotica* and Savigny's other name *virescens*, at least, may be available for the pink morphs, although this will require testing against the type - stated by Reynolds & Cook (1976: 188) to be in "MNHN", Paris. Alternatively, a parthenogenetic species-complex may be prevalent, at least in continental Europe, where larger genetic distances are possible due to polyploidy and lack of back-crossing (Cs. Csuzdi pers. comm. to RJB, 2009).

A recent study by Lowe & Butt (2008) indicated some reproductive separation of *A. chlorotica* green and pink morphs but this would need to be confirmed against molecular evidence from the primary types and the types (or neotypes) of the synonyms and sub-species listed above. This appears to have been attempted, and "*unprecedented sympatric cryptic diversity within British lumbricid earthworms*" was claimed (King, *et al.* , 2008 Ref.) but, yet again, types were untested as the ***starting point*** thus any conclusions are necessarily ungrounded and largely independent of any name that these molecular workers wish to apply to the source of their tissue samples. The solution, as usual, is not as simple as it may appear unless first principles, e.g. '***Principle of Priority***', are sought.

Allolobophora cupulifera Tétry, 1937

Fig. photos of *A. cupulifera* from Ma & Bodt (2002: figs. 1, 2) – rhs specimen is defective.

Fig copy of Ma & Bodt (2002, fig. 1)

Allolobophora cupulifera Tétry, 1937: 119. [Locality France (possibly Nancy). Type in author's collection, probably lost]; Easton, 1983; Blakemore, 2004, 2007.

Koinodrilus cupulifera : Qiu & Bouché, 1998: 111.

Aporrectodea cupulifera : Fauna Europaea, 2004.

Diagnosis [from Qiu & Bouché (1998a: 197 and 1998: 111) - these two accounts differ, but only on important points like the clitellum and tubercula details!]: Length 35-50 mm, width 2-2.5 mm. Segments 80-115. Pigment absent. Prostomium epilobous. Setae closely paired (ratio aa:ab:bc:cd:dd = 9:1:6:1:20). Dorsal pores from 4/5. Male pores reduced on 15. Spermathecal pores 9/10/11 in setal c lines. Clitellum 25,26-32,33. Tubercula pubertatis 29-31,32 with two couples of suckers in 28 & 30 also (cf. *E. japonica* in 27 & 29). Calciferous glands in 10-14 with lateral diverticula in 10. Gizzard in 17-18. Nephridial bladders J-shaped. Seminal vesicles in 9-12.

Ecology & Distribution (from Ma & Bodt, 2002; etc.): Ecological classification of *A. cupulifera* is semi-aquatic and relatively acid-tolerant. The species is relatively rare occurring in localized sites. Distribution is in Germany and the whole Rhine estuary of the Low Countries plus the Seine valley in Upper Normandy. Its range extends from Sweden (listed by Lars Skipper – see Blakemore, 2007) the island of Fynn, and Zealand in Denmark (Linde & Holter, 2002) to Marseille in France. The eastern border is formed by the region of Bonn and the valley of the river Mosel, and into Romania. As yet unreported from UK, Muldowney & Schmidt (2002) recorded it from Ireland: "*at three locations in low-lying, alluvial grassland habitats known as callows along the River Barrow, in counties Kilkenny and Carlow*".

Allolobophoridella Mrsic, 1990

Allolobophora (*Allolobophoridella*) Mršić, 1990: 64.

Type-species: *Lumbricus eiseni* Levinsen, 1884.

Diagnosis: (from Csuzdi & Zicsi, 2003; etc.): Setae closely paired; prostomium tanylobous; spermathecae lacking; nephridia alternate irregularly. Calciferous glands with diverticula in 10-12; nephridial bladder U-shaped. Muscle bundles fasciculated.

Distribution: The type-species, probably with a European origin (or neo-endemic?), is cosmopolitan; the only other species, *Allolobophoridella xylophila* is known from Tunisia and Algeria in North Africa where it occurs under the bark of decaying logs of *Quercus suber* and is used locally for vermiculture of this cork residue.

Taxonomic remarks: This sub-genus, was elevated by Mrsic (1991) to generic status and included two species, *L. eiseni* and *Allolobophora parva* Eisen, 1874, but Mrsic also thought the genus may be a synonym of the now mostly North American genus *Bimastos* and this is where its two species were placed by Qiu & Bouché (1998: 197). Recent reviews return *parva* to *Bimastos* but add a second species to the current genus, *Allolobophoridella xylophila* (Omodeo and Martinucci, 1987) [misspelt and miscited as "*xylophyla* Perel" in Qiu & Bouché (1998: 190); misspelt "*xilophila*" but transferred to *Allolobophoridella* from *Eisenia* by Csuzdi & Zicsi (2003: 69)].

Csuzdi *et al*. (2017: fig. 1) recombined *A. eiseni* in its former home within *Bimastos* confirming its proximity to the type of that genus (*B. palustris*). However, their mtDNA analysis is not conclusive as the two vouchers differ by 2% (see below) and do not convincingly nest within all other members of the genus (and perhaps their specimen of the type, *B. palustris*, is anomolous?) thus *A. eiseni* is here retained on its unique tanylobosity. These authors give no comment on the fate of *A. xylophila.*

Allolobophoridella eiseni (Levinsen, 1884) [now in *Bimastos*]

Fig. 6.2. *Allolobophoridella eiseni* from Strathgordon, Tasmania.

Lumbricus eiseni Levinsen, 1884: 241. [Type locality Deer Garden, Copenhagen. Types 5 of in Copenhagen]; Gates, 1968: 1; Gates, 1978: 115; Sims & Gerard, 1985: 98, fig. 33; Blakemore, 1999: 183; 2000: 33, fig. 23.

Allolobophora (*Bimastus*) *eiseni*: Friend, 1892: 302.

Lumbricus eiseni var. *gracilis* Friend, 1893: 187, tab. 1. ["*Essex specimens of var.* gracilis *are from the side of a ditch, Becton Road, Plaistow Marsh, collected by*

Mr. W. Allen. The type came from an old tree stump in Epping Forest". Type lost?]. **Syn. nov.** [Differs from the nominal subspecies only in 'slenderness'].

Allolobophora eiseni: Rosa, 1893: 462; Easton, 1983: 475 (syn. *rubra* Bretscher, 1900; *eiseni gracilis* Friend, 1911; *merciensis* Friend, 1911; *oltenicus* Pop, 1938).

Helodrilus (*Bimastus*) *eiseni*: Michaelsen, 1900: 503; Stephenson, 1923: 352.

Allolobophora rubra Bretscher, 1900: 454. [Types in Zurich].

Dendrobaena merciensis Friend, 1911: 192. [Types missing].

Bimastos eiseni var. *gracilis* : Friend, 1911: 368. [Sometimes listed as "nom. nud." but actually most likely same as previously described *gracilis* Friend, 1893].

Bimastus oltenicus Pop, 1938: 146 (non *Eiseniella oltenica* Pop, 1938:135). [Types missing].

Bimastus eiseni: Friend, 1911: 145; Omodeo, 1956: 178; Lee, 1959: 357.

Eisenia parva f. typica (part.): Pop, 1950: 89.

Bimastos eiseni: Gates, 1958b: 5; Gerard, 1964: 33; Fender, 1985: 110; Qiu & Bouche, 1998: 197; Csuzdi *et al*. (2017: figs. 1-2).

Eisenia eiseni: Graff, 1953: 27; Zicsi, 1968: 182, 1982: 443; Bouché, 1972: 385.

(Genus?) *eiseni*: Gates, 1972: 128.

Allolobophoridella eiseni: Mrsic, 1991: 255; Csuzdi & Zicsi, 2003: 69-70; Blakemore, 2005; 2006; 2007; 2008: 499; 2010; 2012; 2016.

Taxonomic Note: In a previous revision, Easton (1983: 475) again transferred this taxon to *Allolobophora* from *Lumbricus*, although this was apparently ignored by Sims & Gerard (1985, 1999: 82). It was not certain that *eiseni* belonged in *Allolobophora* as, on balance, it has more characters complying with *Lumbricus*, e.g. tanyloby and red pigmentation; although its U-shaped nephridial bladders are similar to those of the type-species, *Allolobophora chlorotica*. Its transfer to *Allolobophoridella* may not be warranted either (Mršić, 1991). Confusion with the species *Ai. eiseni* was caused by Pop's (1941) synonymy with *Bimastos parvus*. Perel (1979) demonstrated that the two species should be sparated as *Ai. eiseni* has fasciculated and *B. parvus* pinate musculature, as well as these two being tanylobous and epilobous, respectively (Csuzdi & Zicsi, 2003: 71).

Diagnosis: Prostomium tanylobous. Length 30-85. Colour bright violet to dark red-brown or slate, yellowish below. Clitellum over 24,25-32,33. Tubercula pubertatis

absent. Tumescences absent, or around ab on 16, 17, 25. Spermathecae absent. Setae closely paired (5aa=ab=cd=5bc).

Distribution: Widespread in western Europe, in wet acid moorlands, from Denmark to Balkans and Portugal and Poland; British Isles [e.g. Albion, Snaefell on Isle of Man, all major Hebrides except Canna, and other Scottish Islands, Channel Islands (e.g. Herm), Dublin - although a specimen collected from Dublin was mis-identified as *A. parva* by Friend (Gerard, 1964: 35)]; Clare Island (Eire), Madeira, Azores (Gates, 1968: 2), Canaries (Ref.), St Helena; USA (Oregon, Washington, Tennessee and Alaska); Cape Province, South Africa (e.g. Cape Peninsula, Table Mtn.); Naini Tal, India in the western Himalayas. A report (pg. 97) from Hawaii claims "*Sisenia eiseni Levinsen 1884*" (sic) which may (or may not?) actually be *A. eiseni* as a new record. In the Australasian region from Stewart Island and North Island of NZ (Lee, 1959), plus a new record for Australia (Tasmania) – see Blakemore (1996; 1999; 2000b, 2000e).

Habitats: Under moss or decaying leaves; often dominant on moorland; bog; by streams and submerged in roots at 2 m depth in Lake Windermere (Gates, 1972). In Hungary this species lives solely under the bark of decaying logs (Csuzdi & Zicsi, 2003: 71). It is sometimes reported to be truly a tree climbing species.

Location: Strathgordon village, Tasmania, 13.iv.1996, R.J. Blakemore, in garden soil (mature, posterior amputee); QVM 14:3452. UK specimen collected 9th VI, 2013 from Alkington Rd., Whitchurch on patio near flowerpots (Jill & Paul Davey's house).

Length: 30-85 mm.

Width: 2-5 mm.

Segments: 70-115. Body cylindrical.

Colour: Anterior and dorsum red-brown (bright violet to slate), clitellum red or buff.

Prostomium: Tanylobous.

Clitellum: Mostly saddle-shaped, 24,25-31,32,33; slightly converging in the ventrum further posteriorly.

Dorsal pores: 5/6.

Setae: Eight per segment, closely paired; (5:1:2.5:1:10:0.5).

Nephropores: Obvious, irregular in b and above d.

Spermathecal pores: None.

Female pores: Paired on 14 lateral to b setae.

Male pores: Widely paired, lateral slits on 15.

Genital markings: None; tumescences sometimes surround ab on 16, 17, 24, 25.

Septa: 6/7/8/9 only slightly thickened.

Calciferous glands: Large, annular in 10 and 11 (or 10-12?), opening at 10/11.

Gizzard: Intestinal in 16-18, preceded by large "crop" in 15.

Intestinal origin: 15; typhlosole deep, lamellar from 22-24; gut contents organic soil and grits.

Nephridia: Holoic, bladders U-shaped.

Dorsal blood vessel: Single.

Hearts: in 6?,7,8-11.

Male organs: Holandric, testes and funnels in 10 and 11 (although non-iridescent in 10); seminal vesicles rudimentary in 11 and 12.

Ovaries: Huge in 13; small ovisacs in 14.

Prostates: None.

Spermathecae: None.

Remarks: Musculature fasciculate (rather than pinnate as in *Lumbricus*). Supposedly uniparental but spermatophores sometimes present. Chromosome number diploid 2n=32, polyploidy not recognized. Easily confused with *Bimastos parvus* (formerly *A. parva*), and the two taxa were at one time erroneously combined in *Eisenia*, thus some records for *B. parvus* may have been for *A. eiseni*.

Recently Csuzdi *et al*. (2017: fig. 1) recombined *Al. eiseni* in its former home within *Bimastos* confirming its proximity to the type of that genus (*B. palustris*) and to *B. parvus*. However, their mtDNA analysis is not 100% conclusive as their couple of specimens (15811 = KX651385 & 16448 = KX651386) differ by about 2% and do not nest convincingly within all other members of the genus (and perhaps their specimen of the type, *B. palustris*, is anomolous?). Thus *Al. eiseni* is here retained not least on its unique tanylobosity. This, however, does not preclude it originating in North America nor having its closest relations there as possibly a neo-endemic or pre-glacial introduction (or transportee by flotsam or birds) either to or fro from Europe.

Genus ***Aporrectodea*** Örley, 1885

Aporrectodea Örley, 1885: 22; Easton, 1983; Sims & Gerard, 1985; 1999: 53.

Helodrilus + *Allolobophora* (part): Michaelsen, 1900: 479, 480.

[Syns. *Eiseniona* Omedeo, 1956 (type-species: *Allolobophora handlirschi* Rosa, 1897;

syn. *Orodrilus* Bouche, 1972?); *Nicodrilus* (*Nicodrilus*) Bouché, 1972 [type-species: *Enterion terrestre*: Savigny, 1826: 180 (= *A. giardi* Ribaucourt, 1901, see Sims (1973: 30), non *Enterion terrestre* Savigny, 1820 the type of dubius genus *Enterion* (corr. *Enterium*) Savigny, 1920/2: 100/3 – see Michaelsen (1900: 483, 517) and Sims (1973: 30)]; *Nicodrilus* (*Rhodonicus*) Bouché, 1972 (type-species: *Allolobophora arverna* Bouché, 1969); *Koinodrilus* Qiu & Bouché 2000 (type-species *A. georgii*)].

Type-species: *Lumbricus trapezoides* Dugès, 1828 (designated by Gates, 1975).

Diagnosis: Calciferous sacs in 10 discharging into the equator of the oesophagus (or opening widely therein for *rosea*). Calciferous lamellae continue along posterior walls of sacs. Nephridial vesicles J- or U-shaped ducting to bodywall near setal b lines. Nephropores alternate irregularly on each side anywhere above setal lines b and d. Setae closely paired. Prostomium epilobous. Pigment, if present, not red.

Note: There is a possibly insignificant error in the generic definition of Reynolds (1977) and of Sims & Gerard (1985) as the supposedly definitive U-shaped nephridial vesicles are more J-shaped in the type and most other species according to the descriptions of Gates (1972) and some other authors (also see descriptions herein).

Distribution: Europe and Asia-minor. Several species widespread by transportation.

Taxonomic Remarks: Three genera placed in synonymy by Easton (1983: 476) are *Eiseniona* Omodeo, 1956; *Nicodrilus (Nicodrilus)* Bouché, 1972; and *Nicodrilus (Rhodonicus)* Bouché, 1972. Csuzdi & Zicsi (2003) further included *Koinodrilus* Qiu & Bouché, 1998.

An MNHN / INPN French inventory also omits *Nicodrilus* (Ref. - Dec., 2008).

For comments on Savigny's (1820; 1822; 1826) misidentification and misapplication of the name '*terrestris*' for a species now recognized as *A. giardi*, see Michaelsen (1900: 483, 517); Gates (1972: 75); Sims (1973; 1983: 468); Easton (1983: 476); Sims & Gerard (1985: 44) and Bouché (1976). Reynolds (1977: 40) mistakenly cites Bouché's *Nicodrilus* type as *E. caliginosum* Savigny, 1826, but he still accepts synonymy of this genus in the prior *Aporrectodea*.

It was Gates (1975) who first moved *trapezoides* into *Aporrectodea* as the type and transferred many species from *Allolobophora* into this genus.

Csuzdi & Zicsi (2003: 73) provide details of the constituents and composition of this genus (differing slightly from those defined here).

Aporrectodea caliginosa species-complex *sensu* Blakemore, 2002, 2006, 2007, 2008 (i.e., differing from that of Gates or Easton).

Allolobophora caliginosa species-group Gerard, 1964: 27; Sims & Gerard, 1985; 1999: 41, 56.

Allolobophora caliginosa complex Gates, 1972: 84 footnote (inc. *trapezoides, tuberculata, turgida, nocturna, ?limicola, ?longa* - i.e., differing from current concept presented below due to TransAtlantic sense anomalies).

Allolobophora trapezoides group [Gates, 1972: 69 (inc *longa, trapezoides, tuberculata, turgida, limicola, nocturna*)]; 1972a: 1 (inc. *nocturna, trapezoides, turgida, tuberculata*).

Aporrectodea trapezoides species-complex, Easton, 1981: 41 (inc. *caliginosa, trapezoides*).

Aporrectodea caliginosa "*mostly phenotypic*" morphs, Sims & Gerard, 1985; 1999: 41,56 [inc. *caliginosa* (syn. *turgida*)*, tuberculata, nocturna,* ?*trapezoides*].

Aporrectodea caliginosa species-complex Blakemore, 2002; 2006; 2007, 2008 [inc. *caliginosa* (syn. *turgida*)*,* ?*longa, nocturna, trapezoides, tuberculata*].

Diagnosis : (After Michaelsen, 1900; Gates, 1972; Easton, 1981). Colour variable, flesh, grey, brown or dark. Lengths 35-180 mm. Epilobous. Body cylindrical or flattened posteriorly or forming rectangular cross section with setal pairs at corners. Prostomium epilobic. Clitellum 26,27,28,29-33,34,35. Tubercula pubertatis 30,31-33,34; ventral setae on 9-11,12, and some around clitellum, papillated. Male pores on 15 with tumescence often encroaching into 14 and 16. Spermathecal pores in 9/10/11 in setal cd lines. Spermatophores may also be present (around 25-31). First dorsal pore between 6/7-14/15. Setae closely paired. Segments 104-248. Gizzard may be mainly confined to segment 17 (or segments miscounted due to deletion of septum 17/18).

Taxonomic Note: This informal species-group encompasses an *A. caliginosa* species-complex and is modified from the concepts of authors noted above to acknowledge statements, e.g., by Sims (1983: 460), Sims & Gerard (1985: 44-45, 56-57) and Easton (1981), that *caliginosa* Savigny, 1826 is the valid and prior name. Considerations for the promotion of nomenclatural stability are that the ICZN (1999, Article 23.9) conditions for 'prevailing usage' of *turgida* are not met [for instance, since Michaelsen (1900) several authors have correctly applied the name *caliginosa*]. Moreover, suggestions by Gates (1972: 83) that the name *caliginosa* should be suppressed through lack of types, and by Sims & Gerard (1985: 45) that neotypes be designated for the older taxa, are both

unnecessary if type material of *caliginosa* does indeed survive [as listed by Reynolds & Cook (1976: 84) for *caliginosa* in Geneva: MHNG 3/77]. However, full resolution depends at least on inspection of the Savigny's types of *caliginosa* (?and *carnosa*), and designation of a neotype for *trapezoides* – both tasks beyond the resources of the current study – and then the progressive analysis of all successive synonyms.

In the meantime, the pragmatic approach taken here is to adopt Michaelsen's primary groupings, to reject Gates' elevation of *turgida* over the prior *caliginosa* but to largely accept his definition of *trapezoides* separate from *caliginosa* (as per Easton, 1981 cf. Easton, 1983).

The major problem, I believe, is that what I and others refer to as '*trapezoides*' does not occur in the same form in cooler temperate, Occidental regions of Northern Europe/America where *A. caliginosa* is more prevalent and which may possibly have different 'darker' forms (such as those I recently encountered at Mokai, NZ) that are, nonetheless, similar to *A. trapezoides*. Once again, molecular analysis is required from types for full and unequivocable resolution.

Distribution: (Composite for all taxa, regardless of whether endemic or introduced, from Michaelsen, 1900; Gates, 1972; Easton, 1981, etc.) Europe; Iceland, Greenland, Asia, e.g. Japan, Korea and China (inc. Taiwan); Iran; Syria; Palestine including Israel; Sinai peninsula; Africa (Egypt to Morocco and from South to West Africa); St Helena; Canaries; Madeira; Azores; all the Americas; Hawaii; Himalayas; India; Pakistan; Australia; New Zealand (including Chatham Is. from Benham) and various Pacific Isles.

Remarks: Gates (1972: 84; 1972a) proposed the species-complex that he thought comprised of *caliginosa* Savigny, 1826 (that he referred to under the name *turgida* Eisen, 1873), *trapeziodes*, *tuberculata*, *nocturna*, possibly *limicola* and perhaps at times *longa*. Often, *Aporrectodea limicola* and *A. longa* are maintained separately despite their similarity.

For example, Sims & Gerard (1985: 1999: 55) separated these two species from their concept of *A. caliginosa* for which they defined four 'phenotypic morphs':-

(a) *caliginosa* s. strict. (syn. *turgida*). Length 60-85mm; colour pale pink anteriorly, whitish-grey posteriorly; tubercula pubertatis ridge-like over 31-33 often bipartite and divided at ½32; 120-150 segments.

(b) *tuberculata.* Length 50-150mm; colour mainly whitish grey perhaps with brown speckling; tubercula pubertatis extending ½30-½34 formed from two raised triangular areas with apices in 31 and 33; genital tumescences surround ab on 30,

32 and 34; segments (in NZ specimen 111) 145-194. (Note: prostomium has a furrow ventrally i.e. like a furrowed tongue, as seen also in Mokai specimens).

(c) *nocturna*. Length 90-180mm; colour varies to include all other combinations; tubercula pubertatis as in *caliginosa*; genital tumescences surround ab on 29, 30, 32-34; [170 or], 200-246 segments.

(d) *trapezoides*. Length 80-140mm; colour variable including those of all other morphs; tubercula pubertatis extending 30-34; genital tumescences surround ab only on 32-34. Uniquely male sterile morph.

Sims & Gerard's characterization of *trapezoides* is not wholly accepted here, rather synopses by Michaelsen (1900), Gates (1972) and Easton (1981) are used, condensing to:

- *Aporrectodea caliginosa* s. strict. - pale with 2 pairs of TP centred on 31 & 33.
- *Aporrectodea trapezoides* - dark with tubercula pubertatis undivided on 30,31-33,34.

The *nocturna* morph which has been rarely recorded outside the UK, e.g. a few records from Germany and France, is stated by Gerard (1964: 3) to be similar to both the *tuberculata* morph and to *A. longa*. It is here considered closer to, and is compared with, *A. longa*. The overlapping but supposedly distinguishing characteristics of the *tuberculata* and *nocturna* morphs are respectively listed in Remarks under species descriptions of both *A. caliginosa* and *A. longa* below.

The core features used to distinguish the various taxa are summarized in Table 6; and the patterns of genital tumescences are shown in Table 7.

Ploidy: Sims & Gerard (1985) state that *A. caliginosa* has chromosome number 2n = 36 and, according to Gates (1972), so do the *tuberculata* morph (and "*probably*" *turgida*) as well as *A. longa*, and *nocturna* (cf. Gerard, 1964).

Gates (1972) further reports polyploidy for Italian specimens of *A. trapezoides* where triploid 3n = 54 or tetraploid 4n = 72. See also Perel & Bulatova (2007).

Table 6. Characters differentiating *A. caliginosa* species-group s. Blakemore, 2002 [from Chen (1933); Cain (1955); Gerard (1964); Gates (1972 & 1972a); Reynolds (1977)*; Sims & Gerard (1985, 1999); Schwert (1990: 350); and personal observations].

Character	***A. caliginosa* (inc. *turgida*)**	***A. longa***	***A. nocturna***	***A. trapezoides***	***A. tuberculata***
Colour/Pigment	unpigmented	pale to dark, 'head' darkest	Uniform dark brown	usually dark to very dark (gun-metal) grey	unpigmented
Size (Range)mm	<85 (35-180)	90-170	90-180	>80 (80-270)	50-150

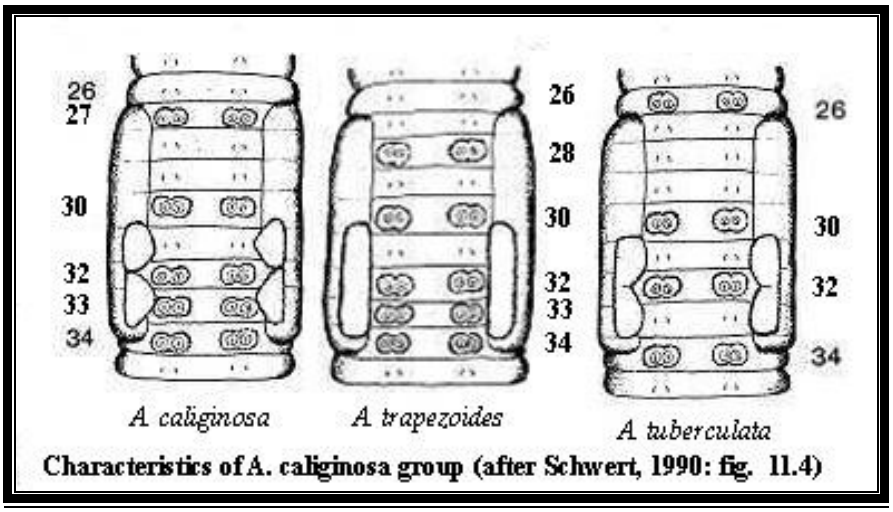
Body shape	usually cylindrical	tail flattens	cylindrical	tail flat or trapezoid	cylindrical or slightly flat
First dorsal pore	6/7-14/15	9/10-14/15	8/9/10	6/7-13/14	9/10-12/13
Clitellum range	24,25,26,27,28, 29-34,35	27,28-35,36	27,28-½35	26,27,28-33,34	27,28-34,35
Tubercula Pubertatis TP	30,31-33,34 interrupted slightly 32	31,32-34 between b and c lines	31 & 33 extending into 32	30,31-33,34 smooth	30,31-33,34 – of double origin
Glandular tumescence GT on 9-11	yes	yes, + rarely on 12	yes + usually on 12	yes	yes, + rarely on 8 or 12
Glandular tumescence usually near clitellum	27, 30, 32-34	31, 33-34	29, 30, 32-34	28, 30, 32-34	26, 30, 32, 34
Diapause	obligatory?	either/or?	?	facultative	facultative
Burrows/ Castings	topsoil/ surface casts	deep/ surface	deep/ surface	topsoil/some surface casts	topsoil/ surface casts
Parthenogenetic	no (never?) spermathecae	no	no	yes (always?)	no? spermatophores
Ploidy	2n = 36	2n = 36	2n = 36	3n = 54 and 4n = 72	2n = 36
Main Climatic range **	Sub-arctic/ Temperate	Temperate/ Mediterr.	Temperate	Mediterr./ sub-tropical	Cold/ Temperate
	***A. caliginosa* (inc. *turgida*)**	***A. longa***	***A. nocturna***	***A. trapezoides***	***A. tuberculata***

*Reynolds (1977) is only partly followed as his figures often have crucial segments miscounted!
**Temperate is understood to refer also to tropical mountinous habitats; Mediterr. = Mediterranean Climate including equivalents in Asia and Australasia.

Table 7. Setae *ab* genital tumescence (not TP) segmental locations in *A. caliginosa* species-complex *sensu* Blakemore, 2002, 2006, 2007, 2008 [modified after Gates, 1972: 69, Tab. 2; those by Schwert (1990, fig. 11.4) –slightly different concepts to Gates' and herein – are **BOLDED**].

Setae *ab* in segs.	*turgida* (= *caliginosa*)	*longa*	*nocturna*	*trapezoides*	*tuberculata*	[*limicola*
9	U	U	U	U	U	U
10	U	U	U	U	U	R
11	U	U	U	U	U	U
12	-	R	U	-	R	U
13-24	-	-	-	-	-	R
25	R	R	-	-	R	
26	R	R	-	-	**C**	R
27	**C**	R	-	R	R	R
28	R	R	R	**O/U**	R	R
29	R	R	C	R	R	C
30	**U**	R	U	**U**	**U**	U
31	R	U	-	-	R	U
32	**U**	-	U	**U**	**U**	U
33	**U**	U	U	**U**	R	
34	**U**	U	U	(**U**)	**U**	
35	R	R	-	O	R	U
36	R	-	-	-	-	C…]

Setal tumescences: - = none; U = usual; C = common (>50%); O = occasional; R = rare.



Characteristics of A. caliginosa group (after Schwert, 1990: fig. 11.4)

In Summary: *A. caliginosa* is pale with ab setal tumescences in often on 27, 30,32-34; *A. trapezoides* is dark with ab setae often on 28, and 30,32-33,34 (as in *A. caliginosa* but with whole area tumid); *A. tuberculata* has them more often in 26 and alternating in 30, 32 and 34.

Note: Gerard (1964), Gates (1972) and Sims & Easton (1985) all had slightly different concepts of the species involved compared to those presented here. Whereas *Ap. caliginosa*, *nocturna, trapezoides* and *tuberculata* all have TP (Tubercula Pubertatis) in 31-33, only *trapezoides* has them un-interrupted across 32. Despite Gates' placement, *Ap. turgida* is now a synonym of *Ap. caliginosa* as explained in the Introduction above.

A. longa appears to differ (?), mostly, by its clitellum extending into 35 or 36 and TP often more restricted to just 32-34, with its prostomium sometimes schizolobous (epilobous with slight extensions to furrows). Several of these characteristics also pertain to other members, segment miscounts (as by Reynolds, 1977!) notwithstanding....

[MOKAI DETOUR with March 2012 update from DNA results – in **BOLD CAPS**]
Here I will take a detour to describe specimens from Mokai, NZ that appear to be different concepts to what is usually encountered as *A. caliginosa* vs. *A. trapezoides*.

Specimens were collected 19-20th October, 2011 from Paerata Rd., Mokai near Taupo across a paddock adjacent to geothermally active mud pool features. A total of twelve 16cm x 16 cm quadrats were extracted from three transects across the paddock. An active paddock population gave sample mean count of 17.9 ± s.e. 2.84 (n=12) worms with biomass of approximately 4.0 g ± s.e. 0.62 (n=7) equivalent to 716 m^{-2} (160 g m^{-2}) and extrapolated to a field population of 7.16 million worms ha^{-2} and 1.6 t ha^{-2} which correspond to Waters' (1955) findings of equivalent to 7.4 m worms ha^{-2}.

Species identified at Mokai were primarily *Aporrectodea caliginosa* species-complex; however two superficial Mokai morphs were recognized as paler *A. caliginosa* and darker, pigmented *A.* cf. *trapezoides*. Other earthworms recovered infrequently were *Lumbricus rubellus*, and *Octolasion cyaneum*.

The difficulty is that the darker specimens do not agree with *A. trapezoides* as usually applied herein. They are smaller and more matt with greater similarity to *A. caliginosa* proper. A conclusion follows the descriptions below.

Samples deposited in Auckland Museum are described below in some detail.

Sample #1. Eight spex ex quadrat A3, mainly dark forms identified in the field as "*A.* cf. *trapezoides*".
Spec.1 (AMNZ 5273) (DNA RJB01 **99-100% AGREE WITH *A. CALIGINOSA***).
Dissected and sketched. Fig. Mokai1 – note the fold in prostomium as also seen in *A. tuberculata*.
Length ca. 50+ mm segs. ca. 143+ (p.a.). Pigment dark matt cocolate brown not shiny gun-metal grey as in *A. trapezoides* 'proper'. Closely tapering epilobic. First dorsal pore 12/13. Segments 9-11 and 15-16 tumid with spermathecal pores in c in 9/10/11. Clitellum 28,29-34; TP 31-33 furrowed in 31/32. Setae ab tumid on segments 26 or 27, 30 and 32-34.

Septa none especially thick; hearts 7-11; seminal vesicles 9-12. Testis iridescent in 10 and 11, free. Ovaries in 13 as usual. Calciferous glands annular in 11 but oesophagus in 10-12 pink and vascularized (only 11 with lamellae, 10 and 12 full of mucus – see figure). Crop in 15-16; gizzard in 17-18 with septum 17/18 aborted

(this a consistent feature); low typhlosole after intestine commences around 19 or 20; gut full of soil only. Spermathecae in 9/10 and 10/11 iridescent. Nephridial bladders thinly J-shaped or fishhooked.

Spec. 2 (AMNZ 5274) (DNA RJB02 – **99% AGREE WITH A. CALIGINOSA**). Sketched but not dissected. Agrees externally (l-50mm s-143).

Spec. 3(AMNZ 5276) (DNA RJB04 – **100% AGREE WITH A. TUBERCULATA**). Partly sketched. Actually a pale specimen found on the road rather than in paddock on 19th Oct., it was lighter pigmented almost pale, and, apart from perhaps having a slightly wider epilobe it appeared exactly the same as the darker specimens. 9-11 were tumid as was 15-16. Setae ab were in tumescences in 18, 19, 25-27 and 30, 32-34. So appears same as darker form! Its tail was broken off and was extra 11 mm and 33 segments. Thus its total length and count were, by coincidence, 51mm and 143. Both Spex 2 & 3 are in Fig. Mokai2.

Sample #2. (AMNZ 5277). Was a single specimen identified as "*A.* cf. *trapezoides*" from B2. Length ca. 50. It agreed externally and had ab setae tumid in 30, 32-34.

Sample #3. (AMNZ 5278). Single specimen identified as "*A.* cf. *trapezoides*" from B3. Length ca. 50. Sample also contains an immature and an *L. rubellus* (AMNZ 5275).

CONCLUSION

These specimens agree with *A. caliginosa*. However, are not quite the same as other *A. caliginosa* mentioned in this Guide, nor are they at all like *A. trapezoides* as used here; possibly they represent domestic NZ ecotypes. Obviously they are a thriving community with a population near the maximum found anywhere in pastures, and this hight density may affect their form: e.g. they may be stunted; or they may be pigmented through diet in these particular soils.

A possibly, which I suspect correct, is they are one of the many synonyms; perhaps Kinberg's (1867) description of *Lumbricus Novæ-Hollandiæ* (sic) from "*Sidney*" or *A. australiensis* (Fletcher, 1886) or almost any other one including Eisen's *turgida*! Possibly DNA samples will help throw light on the mystery of their identity.

YES – SEE CONCLUSIONS IN UPPER CASE ABOVE from DNA DATA BELOW!

>RJB01_A. caliginosa Mokai blast 100% some "A. cal"; but 99% A. cal JN869885 innsbruck

AACCCTATATTTCATTCTTGGAGTCTGAGCCGGCATAGTCGGTGCTGGTATAAGACTTCT
TATTCGAATTGAGCTAAGACAGCCGGGAGCCTTCCTTGGCAGAGATCAACTCTATAATA
CAATCGTTACAGCCCACGCATTCGTAATAATTTTCTTCTTAGTTATGCCAGTATTTATTGG
TGGCTTTGGAAACTGACTCCTACCCCTAATGTTAGGCGCCCCAGACATAGCCTTTCCAC
GCCTAAATAATATAAGATTCTGACTGTTGCCACCCTCGCTAATTCTTCTAGTTTCCTCTG
CCGCTGTAGAAAAAGGAGCCGGAACAGGTTGAACAGTATACCCTCCTCTAGCCAGAAA
TCTTGCACATGCTGGACCTTCAGTAGACTTAGCAATTTTCTCCCTACATTTAGCAGGAG
CCTCCTCCATCCTAGGGGCTATCAATTTTATCACGACTGTAATTAATATACGATGAAGAG
GGTTGCGACTAGAGCGAATCCCTCTATTTGTATGAGCCGTAGTAATTACGGTTGTTTTAC
TCCTCTTATCTCTACCAGTTCTTGCAGGAGCAATTACCATGCTTTTAACAGATCGCAATC
TTAATACTTCATTTTTCGACCCCGCTGGAGGTGGTGATCCCATTCTATATCAACACTTATT
C

>RJB02_A. caliginosa Mokai blast 100% some concepts of “A. cal.” but 99% same RJB1
ANCCCTATATTTCATTCTTGGAGTCTGAGCCGGCATAGTCGGTGCTGGTATAAGACTTCT
TATTCGAATTGAGCTAAGACAGCCGGGAGCCTTCCTTGGCAGAGATCAACTCTATAATA
CAATCGTTACAGCCCACGCATTCGTAATAATTTTCTTCTTAGTTATGCCAGTATTTATTGG
TGGCTTTGGAAACTGACTCCTACCCCTAATGTTAGGCGCCCCAGACATAGCCTTTCCAC
GCCTAAATAATATAAGATTCTGACTGTTGCCCCCCTCGCTAATTCTTCTAGTTTCCTCTGC
CGCTGTAGAAAAAGGAGCCGGAACAGGTTGAACAGTATACCCCCCTCTAGCCAGAAAT
CTTGCACATGCTGGACCTTCAGTAGACTTAGCAATTTTCTCCCTACATTTAGCAGGAGC
CTCCTCCATCCTAGGGGCTATCAATTTTATCACGACTGTAATTAATATACGATGAAGAGG
GTTGCGACTAGAGCGAATCCCTCTATTTGTATGAGCCGTAGTAATTACGGTTGTTTTACT
CCTCTTATCTCTACCAGTTCTTGCAGGAGCAATTACCATGCTTTTAACAGATCGCAATCT
TAATACTTCATTTTTCGACCCCGCTGGAGGTGGTGATCCCATTCTATATCAACACTTATTC

>RJB03_*A. tuberculata* Mt Wellington blast 100% *A. tuberculata* JN869875 / 6 from Klarica in Innsbruck (NOTE, MANY OTHER MATCHES ARE LABELED AS *A. caliginosa*!!)
AACCCTATATTTCATTCTCGGAGTTTGAGCTGGCATAGTAGGTGCCGGTATAAGACTTCT
TATTCGAATCGAGCTAAGACAGCCGGGAGCCTTCCTAGGCAGAGATCAACTCTATAATA
CAATCGTTACAGCCCACGCATTCGTAATAATTTTCTTCTTAGTTATGCCAGTATTTATTGG
CGGCTTCGGAAATTGACTTCTACCCCTAATATTAGGCGCCCCAGATATAGCCTTCCCACG
CCTAAATAACATAAGATTTTGATTGCTCCCCCCCTCGCTAATTCTACTAGTTTCCTCTGCT
GCGGTAGAAAAAGGAGCCGGAACAGGTTGAACAGTCTATCCCCCCCTAGCCAGAAAT
CTTGCACATGCTGGGCCCTCAGTAGATCTAGCTATTTTTTCACTACACTTAGCCGGAGCT
TCCTCTATCCTTGGAGCCATCAATTTTATCACAACAGTAATCAATATACGCTGAAGAGGT
TTACGACTAGAACGAATCCCCCTATTCGTATGAGCTGTAGTAATTACAGTTGTCCTTCTC
CTCCTATCCCTCCCAGTTCTTGCGGGAGCAATTACCATACTTCTAACAGACCGAAATCTT
AATACCTCATTCTTTGATCCTGCTGGAGGGGGTGATCCCATTCTGTATCAACATCTATTC

>RJB04_A. tuberculata Mokai blast 99% A. cal and 99% same RJB01 only 89% same RJB03
So possibly some new and untested entity.
AACCCTATATTTCATTCTTGGAGTCTGAGCCGGCATAGTCGGTGCTGGTATAAGACTTCT
TATTCGAATTGAGCTAAGACAGCCGGGAGCCTTCCTTGGCAGAGATCAACTCTATAATA
CAATCGTTACAGCCCACGCATTCGTAATAATTTTCTTCTTAGTTATGCCAGTATTTATTGG
TGGCTTTGGAAACTGACTCCTACCCCTAATGTTAGGCGCCCCAGACATAGCCTTTCCAC
GCCTAAATAATATAAGATTCTGACTATTGCCCCCCTCGCTAATTCTTCTAGTTTCCTCTGC
CGCTGTAGAAAAAGGAGCCGGAACAGGTTGAACAGTATACCCTCCTCTAGCCAGAAAT
CTTGCACATGCTGGACCTTCAGTAGACTTAGCAATTTTCTCCCTACATTTAGCAGGAGC
CTCCTCCATCCTAGGGGCTATCAATTTTATCACGACTGTAATTAATATACGATGAAGAGG
GTTGCGACTAGAACGAATCCCTCTATTTGTATGAGCCGTAGTAATTACGGTTGTTTTACT
CCTCTTATCTCTACCAGTTCTTGCAGGAGCAATTACCATGCTTTTAACAGATCGCAATCT
TAATACTTCATTTTTCGACCCCGCTGGAGGTGGTGATCCCATTCTATATCAACACTTATTC

[END OF MOKAI DETOUR]

Aporrectodea caliginosa (Savigny, 1826) s. strict.

Fig. 6.3a**.** *Aporrectodea caliginosa* Scullin specimen (a) ventral view, (b) prostomium.
Fig. 6.3b**.** *Aporrectodea caliginosa* Lake Pedder, Tasmania specimen, ventral view with spermathecae and dorsal view of prostomium; compared to AM specimen below.
Fig. 6.3c. *Aporrectodea caliginosa* author's sketch of an Australian Museum specimen, ventral view with spermathecae and a nephridial bladder.

Enterion caliginosum Savigny, 1826: 180. [Type locality in the Paris region. Types, claimed to be missing by some authors, listed by Reynolds & Cook (1976: 84) in Geneva: MHNG 3/77; see also Gates (1972: 83) where he cites designation of a syntype(?) of *carneum* as "lectotype" of *caliginosa* by Cain (1955: 491), and also urges the ICZN to suppress both *caliginosa* and *carnea*; cf. Sims (1983: 469) who supports retention of the name *caliginosa*, and Sims & Gerard (1985, 1999: 44) who prove the validity of Savigy's *caliginosa* yet also advocate designation of neotypes for the oldest names where types are missing. Note that types of synonym, *E. carneum*, are believed still to be in Paris].

Enterion carneum Savigny, 1826: 180 (sometimes page given as "17"). [Type locality Paris. Types in Paris Museum listed as missing (Reynolds & Cook, 1976: 85), but supposed types found there, at least between 1937-1969 (see Tétry, 1937: 146; Cain,1955: 491; Stöp-Bowitz, 1969: 172; Gates, 1972: 83) – the latter author doubting Cain's (1955: 491) act of selecting a lectotype for *caliginosa* from Savigny's *carneum* syntypes]. [Michaelsen (1900: 516) listed this species as *incertae sedis*, (cf. Tétry, 1937: 146), but Easton (1983: 476) placed it in synonymy of *caliginosa caliginosa*; its true status may thus be uncertain].

Lumbricus lividus Templeton, 1836: 235. [Types missing].

Lumbricus gordianus Templeton, 1836: 235. [Types missing]; Johnston, 1865: 63. "*Common in cultivated sandy ground, where it is uniformly found contorted, assuming the appearance of a very intricate knot*" – Templeton.

Lumbricus communis cyaneus Hoffmeister, 1845: 24. [Types missing]. [Non *cyaneum* Savigny, 1826 (= *Octolasion cyaneum*)].

?*Lumbricus helenae* Kinberg, 1867: 98 [Type locality St Helena. Types moved from Stockholm to BMNH:1904.10.5.551 (pers. obs. RJB 20.VI.2013) labelled "*Lumbricus HELENAE Kinberg 1867* TYPES", "*1904:10:5:551 Loc: St Helena Don: Swedish State Museum via Beddard Collection. Ref:* ". One mature

dissected and in two parts in poor condition, plus an immature lumbricid]; Michaelsen (1900: 518) listed this species as *incertae sedis* but Gates (1977) placed it in the *caliginosa* species-complex.

?*Lumbricus hortensiae* Kinberg 1867: 98. [Type locality St Helena. Types in Stockholm].

[*Lumbricus levis* (part) Hutton, 1876/7: 351. From Dunedin, New Zealand - see Benham, 1898 when material was in the Otago Museum; Lee (1959: 369; 1962: 178) says that Hutton's species was found by Benham (1899) to be based on two distinct species, one was *Octochaetus levis* and thus specimen (No. A.56.21) is possibly its name bearing type, the other was *Allolobophora caliginosa* (non type) although this latter specimen is possibly BM: 86:18:27 as inspected by Lee (1962)].

Allolobophora turgida Eisen, 1873: 46. [Type locality unknown but stated as in Sweden (Gates, 1972: 84) or Niagara (Reynolds, 1977: 56). Types not desigated (Gates, 1972: 84) but Niagara material in US National Museum: 1157 (Reynolds & Cook, 1976: 183) although Reynolds (1977: 56) says one specimen is aberrant and the other three are actually "*tuberculata*"]. [Publication date sometimes (mis)quoted as "1874", e.g. by Michaelsen (1900: 482), Gates (1972: 84) and Easton (1983: 479); cf. Sims & Gerard (1999: 54)].

Allolobophora caliginosa var. *turgida* : Ribaucourt, 1896: 52.

Allolobophora turgida f. *tuberculata* Eisen, 1874: 43. [Type localities Mt Lebanon (in New England or New York?), presumably secured on the Massachusetts side, and at Niagara, Canada (Gates, 1972: 79; Reynolds, 1977: 52). Types not listed in Reynolds & Cook (1976) but syntypes stated to be in the US National and Stockholm Museums (Gates, 1972: 79, 83) although Reynolds (1977: 52) says the Scandinavian specimens seem to have first been identified by Eisen as "*Allolobophora cyanea* (Hoffmeister, 1845)" - see also *A. tugida* types]. **Note:** this taxon often retained separately (see entries above and **Remarks** below); misdated "Eisen, 1894" by Gates (1969: 3).

Lumbricus cyaneus: Vejdovsky, 1883: 228 [non *cyaneum* Savigny, 1826 (= *O. cyaneum*)].

Helodrilus (*Allolobophora*) *caliginosus* (part): Michaelsen, 1900: 482-483 [syn.?*gordianus* + *lividus* Templeton, 1836, ?*purus*, *anatomicus* (part); Hoffmeister, 1843: 188 (?non Dugès, 1828 = *A. chlorotica*), *communis anatomicus* (part – see *A. rosea*) + *communis carneus* Hoffmeister, 1845: 27-

28, ?*communis olivaceus* + *communis pelucidus* Eisen, 1845, ?*hortensiae* + *novaehollandiae* Kinberg, 1867, *turgida*, *turgida tuberculata*, *levis* (part), *laevis* (laps. part), *cyaneus* : Vejdosky, 1883, *novaehollandiae* + *australiensis* Fletcher, 1886, *beddardi* Ribaucourt, 1896 (non Michaelsen, 1894), *inflata*]; Smith, 1917: 166 (syns. *turgida, tuberculata, trapezoides*); Olsen, 1940 fig 1.

H. (*A.*) *caliginosa* (*typicus*): Michaelsen, 1900: 483 (syn. *turgida*, "etc."); cf. *H.* (*A.*) *caliginosa trapezoides*.

Allolobophora similis Friend, 1910: 99 (?= *tuberculata*). [Type locality Kew. Types in British Museum BMNH 1923:12:13:35].

?*Allolobophora nocturna* Evans, 1946: 98 [?= *A. giardi* (see *A. longa*)]. [Types in US National Museum and BMNH]; Gerard, 1964: 29; Gates, 1972: 134.

Allolobophora arnoldi Gates, 1952 (9): 1; (10): 2 (?= *tuberculata*). [Type locality Arnold Arboretum, Boston. Type at MCZ Harvard 4441].

Allolobophora molita Gates, 1952: 3. [Locality Arnold Arboretum, Boston. Type at MCZ Harvard].

Allolobophora tuberculata + *A. turgida* (part): Gates, 1972: 79, 84 (*tuberculata* syn. *similis*, *arnoldi*); Gates, 1977 (?syn. *helenae*).

Nicodrilus (*Nicodrilus*) *caliginosus alternisetosus* Bouché, 1972: 333 (?= *nocturna*).

Allolobophora tuberculata + *A. turgida* (part): Reynolds, 1977: 50, 56 (syn. *similis*, *arnoldi*, *alternisetosus*, *molita*).

Aporrectodea caliginosa caliginosa (part?): Easton, 1983: 476 (syn. *carneum* Savigny, 1826; *lividus* Templeton, 1836; *gordianus* Templeton, 1836; *purus* Dugès, 1837; *hortensiae* Kinberg, 1867; *novaehollandiae* Kinberg, 1867 (?part – see *A. trapezoides*); *communis olivaceus* Eisen, 1871; *pellucidus* Eisen, 1871; *turgida turgida* Eisen, 1873; *turgida tuberculata* Eisen, 1874; *levis* Hutton, 1877; *australiensis* Fletcher, 1886; *inflata* Michaelsen, 1900; *borellii* Cognetti, 1904; *similis* Friend, 1910; *remyi* Cernosvitov, 1929; *caliginosa hellenica* Tzelepe, 1943; *nocturna* Evans, 1946; *iowana* Evans, 1948 [= *trapezoides*]; *arnoldi* Gates, 1952; *molita* Gates, 1952).

Aporrectodea caliginosa (part): Gerard, 1964: 27; Sims & Gerard, 1985; 1999: 54 [?syn. *alternisetosus* (?= *nocturna*), *meridionalis* (= *trapezoides*), *trapezoides*, *turgida*, *tuberculata*, *nocturna*) - not all these accepted cf. *Ap. trapezoides*].

Taxonomic Note: The synonymy of this species is indeterminable, even after much field, laboratory, and literature investigation, consequently separation of references to the

various *caliginosa* species-group components is not attempted as this may add to the confusion (cf. *A. trapezoides* synonymy below). For example, the *nocturna* morph of *A. caliginosa* spp-group is similar to *Aporrectodea giardi* (Ribaucourt, 1901), itself similar to *A. longa*. Full taxonomic resolution requires re-inspection of types and/or type-localities, possibly designation of neotypes and probably, after this eco-taxonomic process, recourse to molecuar analysis.

Enterion caliginosum as defined by its original author has paired setae, a clitellum on 27-34, and four pairs of seminal vesicles. Tétry (1937; 1938) claimed tubercula pubertatis in 31-32 but, according to Cain (1955), they are in 31 and 33 (Gates, 1972: 83). Kinberg's (1867) description of *Lumbricus Novæ-Hollandiæ* (sic) from "*Sidney*" was included under *caliginosa* by Michaelsen and Easton but the original description is too vague for adequate characterization and, as with *A. australiensis* (Fletcher, 1886); possibly it belongs in *A. trapezoides* as redefined here, or else it may be *A. longa* or some other morph.

Diagnosis: (Composite from Gates; 1972; Reynolds, 1977; Easton, 1981 and pers. obs.). Length ca. 50-150 mm. Body usually cylindrical (although *tuberculata* morphs may sometimes have slightly flattened tail and cf. often squarish-tailed *trapezoides*). Unpigmented, flesh pink anterior and rest of body pale grey. Clitellum 26,27,28,29-34,35. Tubercula pubertatis 30,31-33,34 but interrupted in 32. Genital tumescences around ab on 9-11, 27, 30, 32-34,35. First dorsal pore usually 9/10-13/14 (range 6/7-14/15).

Distribution: (Composite for all taxa from Michaelsen, 1900; Gates, 1954, 1958; 1972; Easton, 1981;etc.). Europe; Finland; Iceland (*tuberculata*); India e.g. the Great Himalayan National Park; Pakistan, Iran; Syria; the Palestine including Israel (e.g. Csuzdi & Pavlicek, 2005: 88); Sinai peninsula; Qatar; North Africa [Egypt to Morocco, recently dubious claim as *A. borellii* Algeria by Baha (1997)]; South Africa; St Helena; Canaries; Madeira; Azores (interception and recent survey); Americas (e.g. USA, Argentina) also reported from Ecuador, Chile, Brazil, Columbia, Paraguay, Uraguay, and Mexico by Brown & Fragoso (2007); Hawaii; Japan; China; New Zealand; Australia. Gates (1954) reports *A. caliginosa* (and *Lumbricus rubellus*) from: "*Juneau, Alaska, about ten miles to the north, in soil of an abandoned Indian village site (locally known as the Auke village site, Auke Bay), September 11, 1950*."

Michaelsen (1900: 485) for *caliginosa typica* had the distribution in Northern Europe and North America (vs. *trapezoides* which was in Mediterranean, North America,

"*etc*."), while Easton (1981) had it "*cosmopolitan (indigenous to Palaearctic)*".

Australian reports are: NSW (Fletcher, 1886; Barley & Kleinig, 1964; Blackwell & Blackwell, 1989), Vict. (Tisdall, 1985); SA (Barley 1959a), WA, Tas., (NT?); collections from Adelaide, NSW, Vict., Tas. and ACT are new records by current author. Not encountered in the field in Qld in studies by Blakemore (1991-1994).

Localities: Australian: Adelaide, SA (pers. obs., samples also sent to current author for identification from Adelaide by Dr Paul Dalby from his trial sites in March, 1996); Yea, Vict (samples sent by Geoff Hirth); Scullin and Kippax, ACT; Woolnorth and Lake Pedder, Tas.; Budderoo Plateau, Robertson, NSW; Taupo/Waikato, New Zealand (2011).

Habitat: Seasonally abundant in pasture and arable soils and urban gardens; (some reports of presence in sodden habitats may actually refer to *A. limicola*).

Behaviour: Docile but exudes watery fluid when disturbed; often contracts when preserved. Amphimictic. Possibly has obligatory diapause.

Length: Usually 50-85mm; (cf. 40-180, Sims & Gerard; or 35-85 when contracted but relaxed individuals may be 200 mm according to Gates).

Width: 3.5-4 mm.

Segments: 117-150; (120-246, Sims & Gerard; 125-168, Gates).

Colour: Pink and faintly iridescent anterior in life, rest of body grey, clitellum darker.

Prostomium: Open or closed epilobous.

First dorsal pore: 9/10-12/13 inconspicuous; (range 6/7-14/15, Sims & Gerard; Gates).

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired from 2; some ventral setal couples in small tumescences; (ca. 4:1:2:1:12:0.4).

Nephropores: Inconspicuous between c and d lines.

Clitellum: Saddle-shaped, usually ½28,29,30-34,35; (range 27-35 or more, Sims & Gerard).

Male pores: Large equatorial slits in 15, almost lateral within pale highly tumid lips that (usually) encroach into 14 and 16.

Female pores: Small slits lateral to b in 14.

Spermathecal pores: 9/10/11 lateral in cd lines.

Spermatophores: Sims & Gerard (1985, 1999: 56) say that spermatophores, often one or two, are "*usually*" over segments 25-31. Indeed they were found on a specimen from Auckland collected by the author in 2011 but they are perhaps not that common.

Genital markings: Tubercula pubertatis of double origin as large raised paps in bc in 31 and 33, i.e., interrupted or 'waisted' at 32; genital tumescences around ab on 9-11, 27, 30,

32-34,35.

Septa: 5/6-9/10 slightly thickened.

Dorsal blood vessel: Single.

Hearts: 6-11.

Gizzard: 17.

Calciferous glands: Vertical sacs in 10.

Intestine origin (caeca, typhlosole): 20; typhlosole from 21-24.

Nephridia: Holoic with J-shaped bladders; (cf. U-shaped in *tuberculata*).

Male organs: Testes/funnels 10 and 11; seminal vesicles 9-12.

Ovaries: 13.

Prostates: None.

Spermathecae: Two pairs in 10 and 11, short duct to small, spherical ampulla, adiverticulate.

Gut contents: Fine soil.

Notes: Although total species abundance and diversity were lower than in organic sections, *Aporrectodea caliginosa* was numerically dominant in the intensive arable section of Haughley farm at Suffolk, UK (Blakemore, 1981, 1996, 2000). In Queensland studies, soil cores in the glasshouse with mixed populations of *A. caliginosa* (from Adelaide) and *A. trapezoides* may have varied in their reproductive rates due to obligatory diapause or heat stress in *A. caliginosa*. Many reports from Europe testify to especially beneficial effects of lumbricids, particularly the supposedly common *A. caliginosa*, on crop and pasture growth (e.g. Edwards & Lofty, 1977; Lee, 1985; Blakemore, 2000). However, Gates (1972: 85) records (a report from K.S.P. Rao, 1959) that within a period of 25 years to 1958, many acres of land in Himachal Pradesh in India went out of cultivation as a result of appearance of earthworms (as many as 2,500 per m^2 to a depth of 25 cm), that made a fertile soil cloddy and unproductive - he identified a sample of nine supposed culprits as one, *Perionyx* sp., one *A trapezoides* and seven *A. turgida* (= *A. caliginosa*).

Remarks: The single feature most used to distinguish the *tuberculata* morph of *A. caliginosa* is its supposed lack of tumescence around setae ab on segment 33, although "*finding it in a rare individual of* A. nocturna, turgida [= *caliginosa*] *or even* trapezoides *would not be surprising*" and, moreover, "*any one of the clitellar tumescenses of* A. tuberculata *may fail to develop*" (Gates, 1972: 82, 84).

The inadequate characterization of ***A. tuberculata*** morph then, that superimposes

on that of *caliginosa*, from Gerard (1964), Gates (1972), Reynolds (1977) and Schwert (1990) summarizes to:-

Aporrectodea tuberculata (Eisen, 1874)

Fig. 6.3d. *A. tuberculata*, Author's Mt Wellington, NZ specimen with spermatophores.

Fig. 6.3e. *A. tuberculata* sketch from Canadian website (note their *turgida* = *caliginosa*).

(Syns. *similis* Friend, 1910: 99; *arnoldi* Gates, 1952: 1, as listed above and some "*caliginosa*" reports - from Gates, 1958)

Allolobophora turgida f. *tuberculata* Eisen, 1874: 43. [Details of synonymy under *A. caliginosa* above].

Diagnosis: Length 50-150 mm. Segments 145-194. Body usually cylindrical, if flattened then less markedly so than in *trapezoides*. Unpigmented, flesh pink anterior and rest of body pale grey. Clitellum 26,27,28-34,35. Tubercula pubertatis of double origin 30,31-33,34 i.e., mainly 31 & 33 but narrower in 32. Genital tumescences around ab on 9-11, (26), 30, 32, 34. First dorsal pore 9/10-12/13. Nephridial bladders U-shaped (Gates, 1972: 80). Spermatophores found.

Distribution: Gates (1958, 1972) has the distribution of *tuberculata* as Scandinavia (Denmark, Norway, Sweden), Western Europe (e.g. England, Ireland, Germany, Netherlands), Americas [e.g. Canada (very common and found in Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, Quebec, and Saskatchewan), USA, Mexico, Chile], Iran, India (Simla), possibly China (Manchuria), and Australia – NSW; he overlooks Gates (1969: 3) previous report from Juan Fernandez Isls. in Pacific. Reynolds (1977) lists Iceland also. Records from New Zealand by Martin (1977), now confirmed from new material from Mt Wellington, Auckland collected by RJB (14th Oct., 2011 – AMNZ 5266); this specimen was also found to have yellow horny spermatophores on intersegments 27/28 & 28/29.

Notes: Bouché's dubious French "*Nicodrilus* (*Nicodrilus*) *caliginosus* ss. *alternisetosus*" (type OECO 67-370-0112) is a junior synonym of *A. caliginosa* that resembles the *tuberculata* morph and for which Blakemore (2007) says:

> "Ap. calignosa alternisetosa *(Bouché, 1972: 333) (?=* nocturna*) [**species inquirenda** - cited by Easton (1983: 477) but omitted by Qiu & Bouché (1998) possibly because this was originally a varietal name outside of ICZN taxonomy, but the name possibly validated by citation in Reynolds & Cook (1976: 68) and by Easton (1983)]*".

The larger, darker *nocturna* morph is also similar to *tuberculata*, and to *A. longa* from which it is distinguished in **Remarks** after the latter species' account below.

Aporrectodea trapezoides (Dugès, 1828)

Fig. 6.3f**.** *Aporrectodea trapezoides* Samford specimen (a) ventral view showing (b) spermathecae, (c) prostomium (d) a cocoon and (e) the trapezoid shape of posterior.

Fig. 6.3g**.** *Aporrectodea trapezoides* Samford cocoons photograph (rhs).

Fig. 6.3h**.** *Aporrectodea trapezoides* Japanese specimens: (lhs) from Minabe, Wakayama, collector H. Sakai (8.vii.05) under grassland; (rhs) Nagano in apple orchard, collector ESS (15.x.2006). Note apparent slight seminal grooving from male pores and similarity to *A. longa* in some supposedly definitive descriptions.

Fig. 6.3i**.** *Aporrectodea trapezoides* sketch from Canadian website.

Lumbricus trapezoides Dugès, 1828: 289. [Type locality Montpellier. Types missing, however, Gates (1972: 79), Reynolds & Cook (1976: 182) and Blakemore (2002, 2006) all advocated recollection and designation of a Neotype].

?*Lumbricus Novae Hollandiae* Kinberg 1867: 99. [Locality Sydney. Types in Stockholm]. [Correct spelling is "*novaehollandiae*"].

Lumbricus capensis Kinberg, 1867: 100. [Locality Cape of Good Hope (Cape Town) SA. Type moved from Stockholm to London: BMNH 1904:10:5:549 – "*Lumbricus CAPENSIS Kinberg 1867* TYPES", "*1904:10:5:549 Loc: Cape of Good Hope Don: Swedish State Museum via Beddard Collection Ref:* "; a single dissected specimen in poor condition – pers. obs. RJB 20.IV.2013].

Allolobophora caliginosa var. *trapezoides* : Ribaucourt, 1896: 49.

Allolobophora caliginosa beddardi Ribaucourt, 1896: 53. [Berne Alps. Types?]. [Non *Allolobophora beddardi* Michaelsen, 1894 (= *Bimastos parvus*)].

Allolobophora inflata Michaelsen, 1899: 124. [Types?].

Helodrilus (*Allolobophora*) *caliginosus trapezoides*: Michaelsen , 1900: 483 (syn. *beddardi*, *inflata*, "*etc.*"); Olsen, 1940, fig. 1.

Helodrilus (*Helodrilus*) *mariensis* Stephenson, 1917: 414, fig. 6; 1923: 504. [Gates (1958) gives locality as Murree and says types presumed in Indian Museum].

Eophila augilensis Sciacchtano, 1932: 302. [Types?].

Allolobophora caliginosa (Sav.) *trapezoides* (Ant. Dug.): Chen, 1933: 216, figs. 11-12.

Dendrobaena samarigera graeca Cernosvitov, 1938: 191. [Types?].

Allolobophora iowana Evans, 1948: 515. [Types?].

Allolobophora trapezoides: Gates, 1972: 76 (syn. *iowana*).

Nicodrilus (*Nicodrilus*) *caliginosus meridionalis* Bouché, 1972: 334.

Aporrectodea trapezoides: Reynolds, 1977: 46, fig. 10 (syn. *mariensis*, *iowana*, *meridionalis*); Easton, 1981: 41; Blakemore, 2002, 2004, 2005, 2006, 2007.

Aporrectodea caliginosa trapezoides: Easton, 1983: 477 [syns. *capensis* Kinberg, 1867; *beddardi* Ribaucourt, 1896; *mariensis* Stephenson, 1917; *augilensis* Sciacchtano, 1931 (1932?); *samarigera graeca* Cernosvitov, 1938].

Taxonomic Note: Owing to unresolved nomenclatural confusion, not all references to "*A. trapezoides*" in the literature necessarily refer to this species: it is often confused with *A. caliginosa s. strict.* or with the European "*A. caliginosa trapezoides*" 'variety' [sometimes synonymised in *caliginosa* along with *tuberculata*, *turgida* and *nocturna*, e.g. by Sims (1983) and Sims & Gerard (1985)]. This latter concept is seemingly a different species from *trapezoides* under consideration here (also see Gates, 1972 for discussion). No type material of *A. trapezoides* exists to assist clarification, thus resampling of the probable type-locality in the south of France for (amphimixic?) populations may be required to fully resolve this impasse (cf. Gates, 1972: 79). This is the genotype-species.

Diagnosis: (Easton, 1981 and pers. obs): Length 80-140 mm. Body flattened posteriorly to form rectangular cross section. Colour slate, brown, often paler ventrally. Clitellum 26,27,28-33,34 usually 26,27-34 with 30-34 most pronounced. Tubercula pubertatis (30),½30,31-33,½34 [i.e., at least in 31-33 and usually uninterrupted on 32]. Genital tumescences around ab on 9-11, some of 26-29 and 32-34. First dorsal pore 6/7-13/14.

Distribution: As given by various authors, (Michaelsen, 1900): Mediterranean and North America, "etc."; (Easton, 1981): Palaearctic (indigenous), Nearctic, Oriental, Australasian and Neotropical regions. (Gates, 1972): China "*fairly common in most parts*" (e.g. Nanking, Soochow, Hunan, Szechuan, etc.), Japan, Hawaii, North America, Mexico, South America (e.g. Bolivia, Argentina, Brazil, Costa Rica, Guayana, Uruguay, Peru), England, Mediterranean Europe, St Helena, Algeria, South Africa, Lebanon (Gates, 1982), Iran (interception Gates, 1972: 77), Afghanistan, Baluchistan, Pakistan, Kashmir, New Zealand and Australia. Ghilarov & Perel' (1984) cited a report by Wilcke (1966) that *A. caliginosa trapezoides* was found in an isolated oasis in the Sahara. In Australia, reports are: Qld. e.g. Toowoomba (Stephenson, 1933; Thompson, 1992); ?W.A. (Jackson's 1931 account encompasses both this species and *A. caliginosa*), NSW, SA (Barley, 1959a), Vict., Tasmania. Gates (1972: 79) reports this species and *A.*

longa from the stomach contents of Tasmanian bandicoots.

Gates (1967) implies its Colorado introduction relates to the Gold Rush of 1858!

Locality: Brisbane suburbs (e.g. Brookfield), Samford (in very high numbers under river flood litter – some specimens in ANIC), Kingaroy, Gayndah, Mundubbera, Biloela, all in Qld.; Scullin and Kippax, ACT; Budderoo and Broulee, NSW. Japanese specimens: from Minabe, Wakayama, collector H. Sakai (8.vii.05) under grassland (YNU); Nagano in apple orchard, collector ESS (15.x.2006); Ojiyamakoen, Biwako, riverbank in organic debris, collector RJB 2.II.2007, and from soily compost heap on campus of Shiga-ken University, Hikone, collected 2.II.2011 by RJB and MJG, same collectors on 3.II.2011 from paddy embankment at Azuchi-cho, Dainaka, Omihachiman-shi, Shiga-ken (all these latter specimens now in Lake Biwa Museum collection - LBM). Wairakei, New Zealand (coll/ RJB, 13/9/2011, specimen deposited in Auckland Museum AMNZ 5264). Korea, from shrine gardens in SW collected by RJB January, 2012 (specimens in NIBR).

Habitat: Pasture, garden and arable soils, paddy, especially in rich organic soils where there is surface litter and sufficient moisture; Broulee specimes were from sand in drain.

Behaviour: Fairly docile, when alarmed posterior segments contract becoming slightly flattened and spade-shaped.

Length: 60-159 (270) mm. **Width:** 3-7 mm. **Segments:** 130-170, usually 132-159; secondary annulation from 6 (cf. from 13 in *nocturna* according to Gerard, 1964).

Colour: Dark almost gun-metal grey especially in anterior and posterior extremities, iridescent, dorsum; pale ventrum and yellow/buff clitellum. Occasionally lighter grey-brown specimens found.

Prostomium: Closed epilobous.

First dorsal pore: 6/7-13/14 (Gates, 1972) usually from 9/10 or 12/13?, ejecta seen from 14/15; occluded on clitellum.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired from 2, vary in places and couples at corners of trapezoid body in posterior; (20:2:8:1:15:0.2).

Nephropores: Irregularly alternating in b to d setal lines, inconspicuous.

Clitellum: Saddle-shaped, variable (25),26,27-34,(35) usually 26,27-34 with 30-34 most pronounced.

Male pores: Large equatorial slits in 15, almost lateral within pale highly tumid lips that encroach well into 14 and 16.

Female pores: Small slits lateral to b setae on 14.

Spermathecal pores: 9/10/11 near c lines.

Genital markings: Tubercula pubertatis uninterrupted but convoluted ridges occupying bc in (30),½30,31-33,½34; pale, raised tumid pads surround ab in 9-11, some other ventral setal couples e.g. 30, 32, and 33-34 usually in small tumescences also some other segments. Wairakei variety specimens had deep furrow in 31/32 but not bisecting TP (setae tumescences were all of 28-33 – but the whole area was tumid on ventum).

Septa: Visible from 5/6, 6/7-9/10 increasingly muscular.

Dorsal blood vessel: Single.

Hearts: 6,7-11.

Gizzard: 17.

Calciferous glands : Wide vertical in 10 and 11.

Intestine origin (caeca, typhlosole): Near 20; typhlosale present from 21.

Nephridia: Holoic with J-shaped bladders.

Male organs: Testes/funnels 10 and 11; seminal vesicles often small in 9-12.

Ovaries: 13.

Prostates: None.

Spermathecae: Two pairs in 10 and 11, short duct to small, spherical ampulla (sometimes absent).

Gut contents: Fine soil.

Notes: *A. trapezoides* is one of the five species commonly sold and used as fishing bait in North America and year round activity under favourable conditions is reported by Gates (1972) as was also found in Japan – mature specimens found in Lake Biwa region were mature in winter (pers. obs.). Gates also reports that a high proportion of mineral soil is ingested even when organic food is available and that this passes through the gut in 10-20 hours.

Specimens were collected at Samford in large very numbers along with several other species under a carpet of plant debris left by flooding on a pasture; at Kingaroy in sodden soil near a drain in association with *Fletcherodrilus unicus* and other species; from Gayndah, beside a creek; and at Biloela in low numbers in cultivated fields. The Broulee, NSW specimens were found in association with two particularly widespread natives, *Heteroporodrilus oxleyensis* (Fletcher, 1889) and *Anisochaeta macleayi* (Fletcher, 1889), [formerly as *Spenceriella macleayi* that is widespread (translocated?) in Agricultural soils in NSW – see Blakemore & Elton, 1997; Blakemore, 1997b; 2000a:4; 2000c:199; 2006; and now New Zealand – see Blakemore, 2012].

In glasshouse trials of the current author's study (Blakemore, 1994), this species

had a positive influence on plant growth and good survival in both clay and sandy soils. Of the 25 spp tested in a series of laboratory and glasshouse 'screening tests' for controlled introduction this was one of a dozen candidate spp to two sites in Qld (Blakemore, 1994; 1997). After a year, it had good productivity and survival in the field.
Remarks: Gates (1972) stated that: "Pontoscolex corethrurus*, as well as* A. trapezoides*, has been taken around the world during the last four centuries...yet, to this day there is no record of both species from the same site*". However, in the studies reported here these two were found in the same biocoenoses, not least, at Brisbane, Samford, Gayndah and Biloela.

It is believed that *A. trapezoides* is probably the "*caliginosa*" most frequently recorded from Mediterranean countries and this may be the locality of its biparental antecedants. Polymorphic degradation of reproductive structures, as often found in other parthenogens, have not yet been recognized in *A. trapeziodes*, suggesting that its acquistion of this was recent, even thouth Italian triploids were believed to have originated 40 million years ago (reference cited by Gates, 1972: 78).

Specimens were recently recorded in New Zealand plus there were other forms in a pasture at Mokai (Taupo) that differed from the concept presented above of *A. trapezoides* which is often a moderately large and with 'shiny' dark pigmentaion what I called "gun-metal grey". The Mokai worms were smaller on average and appeared to differ in their pigmentation which although dark was more matt grey (not thought from diet) compared to 'conventional' *A. trazezoides*, and in mixed populations from paler commensal *A. caliginosa* morphs, and both clearly differed from *A. tuberculata* as found in Auckland. It is proposed to describe them separately even though no morphological distincion was found, appart from pigmenation and, possibly, some difference of prostomium.
[END OF *A. caliginosa* spp-COMPLEX].

Aporrectodea icterica (Savigny, 1826)

Fig. 6.4a. *Aporrectodea icterica* from Sims & Gerard (1999: fig. 15).
Fig. 6.4b. *Aporrectodea icterica* sketch from Canadian website.

Enterion ictericum Savigny, 1826: 182. [Type locality Valenciennes? Types in Paris].
Allolobophora icterica : Ribaucourt, 1896: 57, fig. 31.

Allolobophora claparedi Ribaucourt, 1896: 85. [Types in Geneva 3/83].

Helodrilus (*Helodrilus*) *ictericus*: Michaelsen, 1900: 484.

Allolobophora capilla Ribaucourt, 1901. [Types?].

Eophila icterica: Gerard, 1964: 44.

Aporrectodea icterica icterica: Easton, 1983: 477 (syn. *claparedi* Ribaucourt, 1896; *capilla* Ribaucourt, 1901).

Aporrectodea icterica: Reynolds, 1977: 40, fig. 6; Sims & Gerard, 1985: 58, fig. 15; Schwert, 1990: 355; Blakemore, 2005; 2006; 2007.

Taxonomic Notes: Easton (1983) lists three sub-species, ***Ap. icterica dicystis*** (Cernosvitov, 1942) [types BMNH 1923:12:31:21:62 (sic) from Reynolds & Cook (1976: 94)]; ***Ap. i. occidentalis*** (Graff, 1957) [types in Lisbon]; and ***Ap. i. pannonica*** (Cognetti, 1906) [types?]. Name sometimes misspelt "icteria" cf. its replacement in *Eophila* herein.

Diagnosis: Length 50-140 mm. Body cylindrical. Unpigmented, grey, brown or yellowish. Clitellum 33,34,35-42,43,44. Tubercula pubertatis 35,36,37-42,43,44. Genital tumescences around cd on 11-14, ab on 11-14 and clitellar segments. First dorsal pore 4/5/6/7. Spermathecal pores in (7/8)8/9/10/11. Prostomium epilobous.

Distribution: Western Europe (see Sims & Gerard, 1985; Curry, 1979), generally rare, e.g. only one record from Denmark, possibly from plant pots in greenhouse; introduced to North America: Canada (Schwert, 1977), New York and Ontario. Apart from records from Portugal, the species is otherwise only known from previously glaciated areas.

Locality: Not found in current studies, but collected in Haughley, Suffolk, UK in 1980 (Blakemore, 1981; 2000).

Habitats: In garden soil, arable land, meadows and orchards.

Behaviour: ?

Length: 50-140 mm.

Width: 3-6 mm.

Segments: 132-200.

Colour: Unpigmented, body grey, brown or yellowish.

Prostomium: Epilobous.

First dorsal pore: 4/5/6/7.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired from 2; (9:1:5:1:30:0.5).

Nephropores: Irregularly alternating in b to d setal lines, inconspicuous.

Clitellum: Saddle-shaped 33,34,35-42,43,44.

Male pores: Large equatorial slits in 15 between b and c within tumid lips that occasionally encroach into 14 and 16.

Female pores: Small slits lateral of b setae on 14.

Spermathecal pores: Two or three (?or four) pairs in 8/9-10/11 in c or cd lines; (Michaelsen says two pairs or two "doublepairs" in 9/10 and 10/11; Reynolds claims three pairs in 8/9/10/11 with sometimes an anterior pair opening in 7/8).

Genital markings: Tubercula pubertatis lateral of b lines in 35,36,37-42,43,44; tumescences around cd on 11-14, ab on 11-14 and some ab couples on clitellar segments.

Septa: ?.

Dorsal blood vessel: Single.

Hearts: 6-11.

Gizzard: 17.

Calciferous glands: 10.

Intestine origin (caeca, typhlosole): ?

Nephridia: Holoic with U-shaped bladders.

Male organs: Testes/funnels 10 and 11; seminal vesicles 9-12.

Ovaries: 13.

Prostates: None.

Spermathecae: Two or three (or four?) pairs.

Gut contents: ?

Notes: This species was probably transported around northern Europe since Roman times and more recently (in last 1,000 years) to North America. It was found to be fairly abundant at the Haughley farm in Suffolk in 1980 (Blakemore, 1981; 2000).

Aporrectodea georgii (Michaelsen, 1890)

Allolobophora georgii Michaelsen, 1890: 3. [Type locality ? Types in Hamburg, 13000].

Helodrilus (*Allolobophora*) *georgii* : Michaelsen, 1900: 482.

Allolobophora georgii var. *transylvanica* Pop, 1938: 141 [Types in British Museum]. [Mistakenly listed as "transvaalensis" in Reynolds & Cook (1976: 182)].

Aporrectodea georgii : Easton, 1983: 477 (syn. *georgii transylvanica* Pop, 1938); Csuzdi & Zicsi, 2003: 81; Csuzdi, 2007 (website); Blakemore, 2007.

Koinodrilus georgii: Qiu & Bouché, 1998a: 181, 187.

Taxonomic Note: *Allolobophora georgii* Michaelsen, 1890 was made type-species of *Koinodrilus* Qiu & Bouché, 1998a: 181, but this genus was placed in synonymy of *Aporrectodea* by Csuzdi & Zicsi (2003: 73).

Diagnosis: Length 24-80 mm. Unpigmented. Clitellum 28,29-35. Tubercula pubertatis two pairs on 31 and 33. Spermathecae two pairs opening in 9/10/11 in cd. First dorsal pore 4/5. Prostomium epilobous. Setae closely paired, (aa=bc, dd=0.5U).

Distribution: Syria, "*Palestine*" (Israel?), Lebanon, Spain: e.g. Valencia and rarely in northwest (Monroy *et al.*, 2003), Canaries (Ref.), northern Africa (Csuzdi), Transylvania, Sicily, and from Cordoba, Argentina. [Friend (1894) referred some worms from Co. Clare, Ireland to *Allolobophora georgii* but these were later removed (by Gerard or Sims & Gerard?) from British Isles' species lists as they were found to be *Aporrectodea caliginosa*].

Locality: Not found in current study.

Habitat: ?

Behaviour: ?

Length: 24-80 mm.

Width: 2.5-4.0 mm.

Segments: 105-150.

Colour: Unpigmented, pale.

Prostomium: Epilobous.

First dorsal pore: 4/5.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired; (ca. aa=bd, dd-0.5U).

Nephropores: (Irregularly alternating in b to d setal lines).

Clitellum: Saddle-shaped, 28,29-35.

Male pores: Confined to 15.

Female pores: On 14.

Spermathecal pores: Two pairs in 9/10/11 in d or cd lines.

Genital markings: Tubercula pubertatis two pairs, sucker-like on 31 and 33; genital tumescences usually around 11ab.

Septa: 6/7-14/15 slightly thickened.

Dorsal blood vessel: ?

Hearts: Last in 11 with extraoesophageals in 12.

Gizzard: In more than one segment (in 17-18 according to Csuzdi).

Calciferous glands: In 10-11 with lateral pouches in 10.

Intestine origin (caeca, typhlosole): (Lamelliform typhlosole).

Nephridia: Holoic (with U- or more likely J-shaped bladders?).

Male organs: Testes/funnels 10 and 11; seminal vesicles four pairs in 9-12.

Ovaries: 13.

Prostates: None.

Spermathecae: Two pairs.

Longitudinal muscle: Pinnate (Csuzdi & Zicsi, 1999: fig. 6.10.1).

Gut contents: Said to be a subsoil species living in mineral layer and prefering moist clayey soils but casting onto the surface.

Notes: The brief description above is taken from Michaelsen (1900) and Csuzi & Zicsi (2003).

I can find few other records for the is relatively widely distributed species, although it appears somewhat similar to both *Aporrectodea jassyensis* and *E. japonica*.

Aporrectodea jassyensis (Michaelsen, 1891)

Allolobophora jassyensis Michaelsen, 1891: 15. [Type locality Jassy, Romania. Types in Hamburg].

Allolobophora (*A.*) *jassyensis* : Rosa, 1893 :8.

Allolobophora jassyensis var. *orientalis* Michaelsen, 1897: 69. [Types Hamburg 4294].

Helodrilus/Allolobophora cavaticus Michaelsen, 1910: 57). [Types missing from Hamburg]. (Note: non *cavaticus* Czerniavsky, 1880: 342).

Helodrilus (*A.*) *jassyensis* + *orientalis* : Michaelsen, 1900: 484.

Aporrectodea jassyensis jassyensis : Easton, 1983: 477 (syn. *jassyensis orientalis*; *cavaticus*); Blakemore, 2004; 2005; 2006; 2007.

Taxonomic Note: Easton (1983) lists sub-species, ***Ap. j. phoebea*** (Cognetti, 1913); and ***Ap. j. sotschiensis*** (Michaelsen, 1910) as also mentioned in Kvavadze (1985: 206) and by Qiu & Bouché (1998: 187), but the latter is probably a lapsus for *Murchieona sotschiensis* (Michaelsen, 1902), and the former taxon, missing from Reynolds & Cook (1976), is sometimes given separate species status.

Diagnosis: Length 50-95 mm. Unpigmented, pinky in life. Clitellum ½28,29-35. Tubercula pubertatis 31,½31,32-34,½35. Genital tumescences around ab on 10-13 and 27,28. First dorsal pore 4/5. Prostomium epilobous.

Distribution: Romania, South Russia, Turkestan (Tashkent), Switzerland (Egelsee), the

Palestine including Israel (e.g. Jericho east of Jordan and several other locations in Csuzdi & Pavlicek, 2005: 89), Lebanon, Egypt (Cairo), also reported once from the Punjab, India (two specimens) (Gates, 1972: 67). Note that the earthworms originally collected from Mr A.S. Ashmore's property in NZ were initially indentified as *A. jassyensis* but later determined to be *A. caliginosa* – see Nielsen (1955).

Locality: Not found in current study.

Habitat: In arable soils.

Behaviour: ?

Length: 50-95 mm.

Width: 2-4 mm.

Segments: 90-139.

Colour: Unpigmented, or pink in life.

Prostomium: Epilobous.

First dorsal pore: 4/5.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment; (aa>bc,dd<0.5U)

Nephropores: ?

Clitellum: Clitellum ½28,29-35.

Male pores: Large equatorial slits in 15 between b and c within tumid lips that occasionally encroach into 14 and 16.

Female pores: On 14.

Spermathecal pores: Two pairs in 9/10/11 in cd lines.

Genital markings: Tubercula pubertatis 31,½31,32-34,½35. Genital tumescences around ab on 10-13 and 27,28.

Septa: 6/7-11/12 thickened.

Dorsal blood vessel: ?

Hearts: ?

Gizzard: ?

Calciferous glands: ?

Intestine origin (caeca, typhlosole): ?

Nephridia: Holoic.

Male organs: Seminal vesicles small in 9 and 10.

Ovaries: 13.

Prostates: None.

Spermathecae: Two pairs.

Gut contents: ?

Notes: The widespread distribution from the Middle East to eastern Europe (and India) qualifies it as a peregrine species.

It differs from members of the *A. caliginosa* species-group on its first dorsal pore in 4/5, and the ventral setae on some of 10-13 and 27-28 being papillated (rather than those in 9-12, and those around the clitellum).

Aporrectodea limicola Michaelsen, 1890

Fig. 6.5. *A. limicola* from Sims & Gerard (1999: fig. 16).

Allolobophora limicola Michaelsen, 1890:10. [Type locality Rolfshagen, Hamburg (or Zurich?). Types in Hamburg, 124]; Gates, 1957, figs. 1-2 (of oesophagus), 3-4 (of typhlosole) [Gates (1957) also online here: Ref.].

Helodrilus (*Allolobophora*) *limicolus*: Michaelsen, 1900: 484.

Aporrectodea limicola: Easton, 1983: 477; Sims & Gerard, 1985, 1999: 60, fig. 16; Blakemore, 2005; 2006; 2007.

Diagnosis (after Gates and Sims & Gerard): Length 40-100 mm. Body cylindrical with enlarged anterior segments. Unpigmented, anterior pinkish the rest of body greyish. Clitellum 28,29-35,36. Tubercula pubertatis 33 and 34. Genital tumescences around ab on some or all of 9-14, 16-17 and 35-38. First dorsal pore 4/5/6. Prostomium epilobous.

Distribution: Scandanavia to Switzerland, Britain and Ireland; introduced into North America (USA: Georgia, Massachusetts, New Jersey, Oregon, Pennsylvania and Washington; Canada: west coast of Vancouver Island BC), Hawaii (Beddard, 1900: 414) and Australia (Adelaide, SA - J. Buckerfield, pers. comm.).

Locality: Not found in current study.

Habitat: Mires, peat bogs, marshes and damp pastures also arable land (although Gates thought this only applied to "*strays*").

Behaviour: Reported from wetland sites, at least in Europe, (*limicola* = mud-living).

Length: 40-100 mm.

Width: 3-4 mm.

Segments: 83-146.

Colour: Unpigmented, anterior pinkish the rest of body greyish.

Prostomium: Epilobous.

First dorsal pore: 4/5/6.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired from 2; (6:1.2:4:1:19:?).

Nephropores: Irregularly alternating in b to d setal lines, inconspicuous.

Clitellum: Saddle-shaped, 28,29-35,36.

Tubercula pubertatis: 33 and 34

Male pores: Large equatorial slits in 15, almost lateral within tumid lips that encroach into 14 and 16.

Female pores: Small slits lateral of b setae on 14.

Spermathecal pores: 9/10/11 in cd lines.

Genital markings: Tubercula pubertatis between b and c lines in 33 and 34; ventral setal couples in small tumescences in some or all of 9-14, 16-17 and 35-38.

Septa: 6/7-9/10 thickened.

Dorsal blood vessel: Single.

Hearts: Present from 7-11.

Gizzard: 17.

Calciferous glands: Wide in 10 and in 11-12 too.

Intestine origin (caeca, typhlosole): 15, typhlosole present.

Nephridia: Holoic, vesiculate with U-shaped bladders.

Male organs: Testes/funnels 10 and 11; seminal vesicles 9-12.

Ovaries: 13.

Prostates: None.

Spermathecae: Two pairs in 9 and 10, short duct to small, spherical ampulla.

Gut contents: ?

Notes: *A. limicola* may be more common than the few records would suggest, due possibly to its superficial resemblance to *A. caliginosa* (unlike *D. attemsi* that may be over-reported due to its similarity to *A. caliginosa*). A peat bog in Boston, USA had a dense population associated with other introduced lumbricids (Gates, 1957).

Aporrectodea longa (Ude, 1885)

Fig. 6.6. *A. longa* from Sims & Gerard (1985, 1999: figs. 17-18).

Enterion terrestre Savigny, 1826: 180 (err. non Linnaeus, 1758 nec Savigny, 1820/2:

100/3 – see Michaelsen, 1900: 483, 517 and Sims (1973: 30) – misid.).

Lumbricus terrestris: Dugès, 1837: 17,18 (non *L. terrestris* Linnaeus, 1758) - misid.

Lumbricus Agricola: Hoffmeister, 1845: 5-21, fig. 1a-c (non Hoffmeister, 1842) - misid.

Allolobophora terrestris (Savigny, 1826) f. *longa* Ude, 1885: 136. [Type locality, a garden, Göttingen. Types lost]. (Non *L. terrestris* Linnaeus, 1758).

Lumbricus (*L.*) *terrestris* + *L.* (*Allolobophora*) *longus*: Vaillant, 1889: 121, 113.

Allolobophora lactea Friend, 1892: 89. [Types?]. (Non *lacteus* Örley, 1881).

Allolobophora terrestris: Rosa, 1893: 424, 444 (non *L. terrestris* Linnaeus, 1758); Ribaucourt, 1896: 39.

Helodrilus (*Allolobophora*) *longus*: Michaelsen, 1900: 483 [syn. *terrestre* (non Savigny, 1820), *agricola* (non Hoffmeister, 1842), *lactea*]; Smith, 1917: 167.

Octolasium intermedium Friend, 1909: 357. [Types BMNH 1923:12:31:297]. [Et *intermedia* ; non *Lumbriculus intermedia* Czerniavsky, 1880 (microdrile); nec *Eiseniella intermedius* Jackson, 1931 (sic)].

[*Allolobophora terrestris* Savigny f. *typica*: Tétry, 1937: 57 (superfluous name)].

Allolobophora terrestris Savigny f. *longa*: Tétry, 1937: 58.

Allolobophora longa: Gerard, 1964: 28 (syn. *terrestris* f. *longa* Ude, 1885); Stöp-Bowitz, 1969: 197 (miscited as "Ude, 1886"), fig. 18; Gates, 1972: 73.

Nicrodrilus (*Nicrodrilus*) *longus longus*: Bouché, 1972: 322.

Nicrodrilus (*Nicrodrilus*) *longus longus ambiguus* Bouché, 1972: 323 [invalid name].

Nicrodrilus (*Nicrodrilus*) *longus longus amplisellus* Bouché, 1972: 323 [invalid name].

Nicrodrilus (*Nicrodrilus*) *longus ripicola* (sic) Bouché, 1972: 325. [Types in France].

Nicrodrilus (*Nicrodrilus*) *longus ripicola viridis* Bouché, 1972: 325 [invalid name].

Aporrectodea longa: Sims & Gerard, 1985; 1999: 62, figs. 17, 18 (syn. *Nicodrilus longus longus* Bouché, 1972: 322); Reynolds, 1977: 43, fig. 8A,B [segments miscounted and also with an extra preclitellar segment added in one figure – see Ref.]; Csuzdi & Zicsi (2003: 90) (syns. *lactea, intermedium, ambiguus, amplisellus, ripicola, viridis,* i.e., several synonyms, including invalid Bouché names); Blakemore, 2004; 2005; 2006; 2007, 2008, 2010 (with current syns.).

Aporrectodea longa longa: Easton, 1983: 477 (syn. *lactea* Friend, 1892, *intermedium* Friend, 1909).

Taxonomic Notes: A subspecies listed by Easton (1983) as ***A. longa ripicola*** (Bouché, 1972) was recombined into *A. longa* by Csuzdi & Zicsi (2003: 90). Similar with the *nocturna* and *tuberculata* phases of *A. caliginosa* species-complex;

Aporrectodea longa has often been confused in France with *Aporrectodea giardi* Ribaucourt, 1901 (formerly known erroneously as '*Allolobophora terrestris* (Savigny, 1826)'. [For details, see Gates, 1972: 76; Sims, 1983; 1983: 468; Easton, 1983: 477; Sims & Gerard, 1985:44, (see also Remarks below)].

Diagnosis (after Stöp-Bowitz, 1969; Gates, 1972; Sims & Gerard, 1999): Length 90-250 mm. Body long and flattened posteriorly to form shovel-shaped tail. Colour pale brown to dark reddish brown with anterior dorsum ('head') darkest. Clitellum 27,28-35,36. Tubercula pubertatis 31,32-34. Genital tumescences around ab on 9-11,12, and 31, 33-34. First dorsal pore 9/10-14/15. Prostomium epilobous.

Distribution: Palaearctic from Scandinavia, Iceland, and throughout the British Isles to northern Italy, Russia to Siberia; North and Central America; Algeria, South Africa Reinecke & Ryke (1969), throughout New Zealand (including Kermadec isles) and "***Australia (including Tasmania)***" – these records from Sims & Gerard (1985, 1999: 64). Australian reports are from every state and most territories, e.g. NSW, Victoria, Qld (Fletcher, 1886a: 546; Wood, 1974; Tisdall, 1985; Blackwell & Blackwell, 1989; Robertson, 1991), also SA (J. Buckerfield, pers. comm.), WA (McCredie & Parker, 1988), Tasmania, NSW and ACT (pers. obs.). Most recently collected from a drainage ditch at facility in Lidcombe, NSW (coll. and ID by RJB Jan, 2011 for Fleur Pablo & Amanda Rose at NSW Dept. Environment, Climate Change and Water, Sydney). A report from Landcare Tasmanis is that their DNA barcode of specimens conformed to records of *A. longa*.

The distribution range of *A. longa* includes all of the French Riviera extending into Spain and Italy, as well as being widely introduced extratropically by man in North America (e.g. Indiana, Maine, California; Alberta, New Brunswick (Grand Manan Island), Nova Scotia, Ontario, Toronto, Prince Edward Island, and Quebec), Mexico, South America, Africa, Asia and Australia [see Smith (1917: 167]; Csuzdi & Zicsi (2003: 91; fig. 6.13.3); Sims & Gerard (1985, 1999)].

NOTE: Continued claims from certain Australian worker that *A. longa* occurs only in Tasmania are erroneous, as has been frequently shown and published e.g. by those cited above plus Blakemore (1996; 1999; 2000: 2002; 2005) and Blakemore & Paoletti (2006).

Locality: Tasmanian specimens sampled by the author under pasture turf at Woolnorth at northwest tip of Tasmania (surprisingly superficial and in relatively high numbers in surface turf, especially since it is considered a "*deep-burrowing*" species) – these were not positively identified as no funding was provided for such a basic service.

Nevertheless, specimens confirmed from my backyard garden in Invermay, Tasmania (along with *L. terrestris*), and various other sites including a garden in Holt, north Canberra, ACT (pers. obs. R.J.B., 1999), recently collected (RJB, 17th Jan., 2011) from a flood drainage ditch at NSW Dept. Environment facility in Lidcombe along with specimens of *Anisochaeta* cf. *macleayi*.

Habitats: Abundant in farm and garden soils; also in embankments of watercourses.

Behaviour: When alarmed posterior segments contract becoming flattened and spade-shaped (resembling *L. terrestris*); diapause either obligatory of facultative (Gates, 1972: 75). Csuzdi & Zicsi (2003: 91) call it a "*synanthropic species...common in pastures, gardens and forests…primarily geophagous, but sometimes produce litter-middens dragging leaves from the surface into the burrows… defecates onto the surface, sometimes in great quantities*". Kretzchmar (1991) discusses its burrowing habits while Stöp-Bowitz (1969: 201) calls it "*a pronounced leaf-eater*".

Length: 90-250 mm.

Width: 4-9 mm.

Segments: 145-222, usually tri-annulate.

Colour: Pale brown to dark reddish brown, especially in anterior; iridescent

Prostomium: Epilobous, usually closed but classed as 'schizolobous' where two longitudinal furrows continue to diverge some distance beyond the transvers furrow that bisects them (cf. tanylobous in *L. terrestris*).

First dorsal pore: 9/10-14/15, but usually 12/13.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired from 2; (12:1.5:6:1:20:0.5); ventral setae on 9-12 and on some or all of 30-34 on papillae.

Nephropores: Irregularly alternating in b to d setal lines, inconspicuous.

Clitellum: Saddle-shaped, 27,28-35,36; (cf. Gates 26,27-34,35,36); Sims & Easton (1999: fig. 18) shows it from ½29-½35 but describe it at 27,28-35,36; Reynolds (1977) also fluffs the counts.

Male pores: Large equatorial slits in 15, almost lateral within pale highly tumid lips that encroach into 14 and 16.

Female pores: Small slits lateral and above b setae on 14.

Spermathecal pores: 9/10/11 above c lines.

Genital markings: Tubercula pubertatis occupying bc in 31,32-34; some ventral setal couples in small tumescences e.g. 9-11,12 and 31, 33-34 also some other locations.

Septa: 5/6-8/9,9/10 increasingly thickened.

Dorsal blood vessel: Single.

Hearts: 6-11.

Gizzard: 17-18, (crop in 15-16).

Calciferous glands: Vertical sacs in 10, (glands in 10-12).

Intestine origin (caeca, typhlosole): 15; typhlosole from 23,24, bifid.

Nephridia: Holoic with J-shaped bladders.

Male organs: Testes/funnels free in 10 and 11; seminal vesicles 9-12 those in 9 and 10 smaller.

Ovaries: 13.

Prostates: None.

Longitudinal muscle: Pinnate (Csuzdi & Zicsi, 1999: fig. 6.13.1)

Spermathecae: Two pairs in 9 and 10, short duct to small, spherical ampulla.

Gut contents: Soil or organic debris

Note: Subject to either facultative of obligatory diapause, this species is believed to be responsible, (along with *nocturna*?), for much of the surface casting about which Darwin (1881) wrote. It is also reported to maintain near permanent burrow systems to a depth of 40-60 cm when it processes much soil, to feed selectively on the surface, and possibly leave a 'midden' around burrow entrances, as does *L. terrestris*, although unlike *L. terrestris*, it more modestly copulates below ground (Gates, 1972: 75, 120). Reports suggest it is disturbed by cultivation. In the Haughley studies reported by Blakemore (1981; 2000) it was distributed across all sections of the farm but was especially abundant in the permanent pasture and numbers were lower in the intensively cultivated section.

In an attempt to ape projects in other countries (e.g. NZ), in Australia there has been an extensive (10 year +) and expensive (perhaps AUS $1m) program to 'introduce' this 'deep-burrowing' lumbricid from Tasmania to the mainland in order to increase pasture production - even though it already occurs in every Australian mainland state (see Blakemore & Paoletti, 2006)! The rational was stated thusly: "A. longa *is currently restricted to Tasmania*". Another premise was that there were no deep-burrowing species on the mainland, although several natives appear to meet this criterion (e.g. *Megascolex imparicystis* that burrows to 5 m; *Heteroporodrilus bongeen*; *Digaster* spp.; *Anisochaeta* spp. and some *Diplotrema*). Moreover, the *'A. longa*' source material from Woolnorth, NW Tasmania was obtained from superficial turfs and appeared not deep-burrowing at all (pers. obs. 1994). Identification of this source materials was, to

the best of my knowledge, also unchecked by dissection by a competent taxonomist. Such huge resources could have more readily paid for full surveys of the mainland, to not only determine the true distribution of *A. longa* proper there, but also to find suitable native candidate species and management means to encourage their spread to pasture soils in order to increase production, as indeed was attempted by Blakemore (1994; 1997).

Remarks: With its flattened tail and dark pigmentation, this species is superficially similar to *A. trapezoides* and *Lumbricus terrestris* and to the larger *nocturna* phase of *A. caliginosa* spp-complex which supposedly shares a deep-burrowing and surface casting behaviour (Sims & Gerard, 1985, 1999: 57).

However, it is also possible that the *nocturna* morph is in the ambit of *Aporrectodea giardi giardi* (Ribaucourt, 1901) [syns. (after Easton, 1983: 477) *terrestre*: Savigny, 1826: 180; *bretscheri* Cognetti, 1903; *longus occulatus* Cognetti, 1904]. According to Sims & Gerard (1985: 64), from *Ap. longa* "*the French species is known to differ, among other characters, by additionally having tumescences around setae ab on segments 12 and 30*." Yet, these same tumescence locations are said to be usually characteristic of *Ap. nocturna* by Gerard (1964: 29) and Gates (1972: 69). Further work is required to resolve its full relationships, but the current diagnosis of *nocturna* (especially from Gerard, 1964 and Gates, 1972) is:

> ***Aporrectodea nocturna***. Length 90-180 mm. Segments 170-250. Body cylindrical. Prostomium epilobous. Whole body dark reddish brown. Clitellum ½27,28-½35. Tubercula pubertatis 31 and 33, extending into 32. Genital tumescences around ab on 10-12, and 29, 30, 32, 33 and 34. First dorsal pore 8/9/10 (cf. 12/13 in *A. longa*). [Types in US National Museum and BMNH].

Distribution of *Ap. nocturna* from Gerard (1964) is British Isles, Germany, France. Sims & Gerard (1985: 57) suggest that ecologists may wish to record "*nocturna*" separately if its behaviour influences experimental results.

The '*Ap. nocturna*' morph, identifed using Gerard's (1964) key, was in low numbers only in the 1,000 year-old permanent pasture at Haughley, Suffolk, UK during a study on organic vs. conventional farming there (Blakemore, 1981; 2000).

Aporrectodea rosea (Savigny, 1826)

Fig. 6.7a *Aporrectodea rosea* Samford specimens (a) lateral view, (b) ventral view, (c)

spermathecae.

Fig. 6.7b. *A. rosea* sketch from Canadian website (note their *bowcrowensis* = *rosea* and their figure also superficially agrees with the figure above).

Enterion roseum Savigny, 1826: 182. [Locality Paris. Types in Paris Museum].

Lumbricus roseus : Dugès, 1837: 8, 17, 20. [Non *L. roseus* Risso, 1826 which is listed as *incertae sedis* in Michaelsen (1900: 518)].

Lumbricus communis anatomicus Hoffmeister, 1845: 28 (part – see *A. caliginosa*). [Types missing]. [Non *anatomicus* Dugès, 1828 (= *A. chlorotica*)].

Lumbricus communis carneus Hoffmeister, 1845: 28 [Types missing]. [Non *carneum* Savigny, 1826 (= *caliginosa*)].

Allolobophora mucosa Eisen, 1874: 47. [Types missing]. [Note: date sometimes given as 1873, e.g. Reynolds & Cook (1976: 141) cf. Reynolds (1977: 37) who (erroneously) included this taxon in synonymy of *A. chlorotica*].

Lumbricus aquatilis Vejdovsky, 1875: 199. [Types?].

Allolobophora mediterranea Örley, 1881: 286. [Types BMNH 1881:7:8:2]. [Sometimes listed as *incertae sedis*].

Allolobophora (*Notogama*) *rosea*: Rosa, 1893: 424.

Allolobophora rosea macenonica Rosa, 1893: 428; Gerard, 1964: 33. [Types Hamburg 4492].

Allolobophora Danieli Rosai de Ribaucourt, 1896: 39. [The name now formulated as "*danielirosai*" or "*danielirosae*" (laps.?), From the Alps. Types?].

Allolobophora alpestris Bretscher, 1899: 420. [Alps. Types Hamburg 5104].

Eisenia rosea: Michaelsen, 1900: 478; Tétry, 1937: 143; Lee, 1959: 361; Gates, 1972: 104, 108 (syn. *indicus*); Gates, 1974a: 9; Reynolds, 1977: 78 [syn. *aquatilis*, *carneus* (err. non *carneum* Savigny), *aguatilis* (err?), *danieli rosai*, *bimastoides*, *indicus*, *prashadi*, *hataii*, *harbinensis*, *dairenensis*, *jeholensis*, *kulagini*, *rosea* var. *alpina*, *rosea vedovinii* Bouché, 1972]; Easton 1981: 45; Blakemore, 1999: 183.

?*Allolobophora rosea bimastoides* Cognetti, 1901: 17. [Types?].

Allolobophora nobilii Cognetti, 1903: 2. [Types Turin 250].

Dendrobaena/*Helodrilus diomedaeus* Cognetti, 1906: 1. [Types Turin 767].

?*Helodrilus* (*Bimastus*) *indicus* Michaelsen, 1907: 188. [Type locality (Bengal, Calcutta), India. Types in Hamburg, 7155 and Calcutta, 2876]. [Cf. *Healeyella*].

Eisenia rosea budensis Szüts, 1909: 129. [Types lost]. [Placed in synonymy of *Ap.*

rosea rosea by Csuzdi & Zicsi (2003: 92). Reynolds & Cook (1976) overlook].

Eisenia rosea croatica Szüts, 1909: 129. [Non Rosa, 1895]. [Ditto *budensis*].

Eisenia rosea glandulosa Friend, 1910: 329. [Type BMNH].

Eisenia rosea carnea Friend, 1911: 189 [nom. nud. Non *carneum* Savigny].

Eisenia rosea prashadi Stephenson, 1922: 440. [Gundarbal, Kashmir. Types Calcutta 697 and several in BMNH; said to lack spermathecae].

Eisenia rosea f. *typica* + *E. r. f. macedonica* + *A. hataii* + *A. harbinensis* + *A. dairenensis* + *A. jeholensis* Kobayashi, 1940: 288-293. [Types?]. [Overlooked by Reynolds & Cook (1976)].

[*Eisenia rosea balcanica* Cernosvitov, 1942: 223. [Types BMNH 1949:12:12:51-83]. Included in synonymy by Csuzdi & Zicsi (2003: 92), cf. ***Ap. rosea leocernosvitovi*** Blakemore, 2004: 78].

Eisenia rosea paucipartita Tzelepe, 1943: 1. [Types?].

Allolobophora rosea: Pop, 1948: 69; Gerard, 1964: 23; Stöp-Bowitz, 1969: 188; Bouché, 1972: 418; Zicsi, 1982: 437.

Eophila kulagini Malevics, 1949: 399. [Types?]. [Reynolds & Cook (1976) overlook].

Allolobophora rosea ss. *lusitana* Graff, 1957: 301. [Types in Lisbon]. [?Non *Dendrobaena lusitana* Graff, 1957: 303].

Eisenia rosea dendrobaenoides Omodeo, 1950: 1-12. [Types?]. [Reynolds & Cook (1976) overlook].

Eiseni jenensis Fueller, 1953: 52. [Types?].

Eisenia moderata Chekanovskaya, 1959: 350. [Types?].

Allolobophora rosea interposita Plisko, 1965: 415. [Types in author's collection].

Allolobophora rosea troglodyta Alvarez, 1971: 11. [Types?]. [Overlooked by Reynolds & Cook (1976)].

Aporrectodea rosea: Gates, 1976: 4; Sims & Gerard, 1985: 65, fig. 19 (syn. *rosea macedonia* Rosa, 1893).

Aporrectodea bowcrowensis Reynolds & Clapperton, 1996: 77. [From an unglaciated area of the Porcupine Hills, Alberta. Types?]. Qiu & Bouché, 1998: 187 (as *Nicodrilus* (*Nicodrilus*) *bowrcowensis* (laps.)). [Placed in synonymy of *Ap. rosea rosea* by Csuzdi & Zicsi (2003: 93) but misspelt "*bowcowensis*" (laps.). Clitellum on 25-32 and TP on 29-30].

Aporrectodea rosea rosea: Easton, 1983: 477 (syn *mucosa* Eisen, 1874, *aquatilis* Vejdovsky, 1875, *mediterranea* Örley, 1881, *rosea macedonica* Rosea, 1893, *danielirosae* Ribaucourt, 1896, *alpestris* Brescher, 1899, *nobilii* Cognetti, 1903, *diomedaeus* Cognetti, 1906, *rosea glandulosa* Friend, 1910, *prashadi* Stephenson, 1922, *rosea storkani* Cognetti, 1934, *darienensis* Kobayashi, 1940, *harbinensis* Kobayashi, 1940, *hataii* Kobayashi, 1940, *jeholensis* Kobayashi, 1940, *rosea paucipartita* Tzelepe 1943, *rosea dendrobaenoides* Omodeo, 1950, *jenensis* Fuller, 1953, *moderata* Csekanovszkaja, 1959; *rosea interposita* Plisko, 1965); Csuzdi & Zicsi, 2003: 92; Blakemore, 2004; 2005; 2006; 2007 (syns. *mucosa* Eisen, l874; *aquatilis* Vejdovsky, 1875 [misspelt "aquatlis" by Örley, 1885]; *mediterranea* Örley, 1881; *rosea macedonica* Rosa, 1893 [non *Allolobophora macedonica* Sapkarev, 1971 (= *Helodrilus balcanicus*)]; *danielirosai* Ribaucourt, 1896; *alpestris* Bretscher, 1899; *nobilii* Cognetti, 1903; *diomedaeus* Cognetti, 1906; ?*indicus* Michaelsen, 1907 [this synonym advocated by Gates (1972: 107) but rejected by Cs. Csuzdi, pers. comm.; cf. genus *Healyella*]; *rosea budensis* Szüts, 1909 [placed in synonymy by Csuzdi & Zicsi (2003: 92)]; *rosea glandulosa* Friend, 1910; *prashadi* Stephenson, 1922; *dairenensis* Kobayashi, 1940: 291; *harbinensis* Kobayashi, 1940: 290; *hataii* Kobayashi, 1940: 288; *jeholensis* Kobayashi, 1940: 293; *rosea paucipartita* Tzelepe, 1943 (sometimes spelt “pauci partita”); *rosea dendrobaenoides* Omodeo, 1950; *jenensis* Fuller, 1953; *moderata* Chekanovskaya, 1959 [author's name misspelt "*Csekanovszkaja*" in Easton (1983: 477)]; *rosea interposita* Plisko, 1965; *Ap. bowcrowensis* Reynolds & Clapperton, 1996: 77 (this latter synonymy by Csuzdi & Zicsi (2003: 93) who misspell the name “*bowcowensis*” but also note lapus “*bowrcowensis*” by Qiu & Bouché, 1998: 187)].

Taxonomic Notes: *Ap. rosea* was previously included in *Eisenia* but was officially transferred to the genus *Aporrectodea* by Gates (1976) who earlier (1974a) provided about four pages of synonyms. However, some authors yet retain it in *Eisenia* (perhaps due to its anterior dorsal pores?); cf. Qiu & Bouché (1998: 187) who place it in their new genus *Koinodrilus* – this unacceptable here.

Due to the extremely chequered nomenclatural history of this species, only an abbreviated synonymy is provided above, mainly from Gates (1974a), also from Easton (1983) and Csuzdi & Zicsi (2003). In the past *rosea* has been associated with these

genera: *Allolobophora*, *Bimastos*, *Eisenia*, *Eiseniella*, *Enterion*, *Helodrilus*, *Lumbricus*, *Notogama*; and these species names: *acystis, alpestris, alpina, aquatilis, balcanica, bimastoides, budensis, croatica, dairenensis, danieli rosai, dendrobaenoides, diomedaea, glandulosa, harbiensis, hataii, indicus, interposita, jeholensis, jenensis, lusitana, macedonica, mediterranea, moderata, mucosa, nobilii, paucipartita, prashadi, storkani.* In addition, *Helodrilus norvegicus* Friend (?non *norvegica* Eisen, 1874 nec Bretscher, 1899) is an abnormal specimen almost certainly of *rosea* (see Gerard, 1964: 51) and a recently described *Aporrectodea bowcrowensis* Reynolds & Clapperton, 1996 from Canada is yet another synonym listed by Csuzdi & Zicsi (2003: 93).

Gates (1972: 108) said that his synonymy in *rosea* of *Helodrilus indicus* Michaelsen, 1907 was not accepted by all authors, indeed Easton (1983: 478) appears to have resurrected this taxon and transferred it as *Dendrobaena indica* whereas this synonymy was rejected by Dr Cs. Csuzdi (pers. comm.); cf. genus *Healyella*. Regardless of its generic status, *H. indicus* or *D. indica* can no longer be thought to have been endemic to India and thus neither is the family Lumbricidae. This taxon is briefly considered separately under genus *Helodrilus* below.

Some current reports still have *rosea* in either of the genera *Aporrectodea*, *Eisenia* or *Nicodrilus* and recently Qiu & Bouché (1998) precipitously transferred it to their new genus *Koinodrilus* (that is a synonym of *Aporrectodea*, as with *Nicodrilus*).

The current author's (RJB) preference would be to retain *rosea* in *Eisenia* - where at least it shares with the type-species the anterior commencement of wide dorsal pores in 4/5, a useful character for field identification, but, in the interests of taxonomic universality and stability, it is herein listed in *Aporrectodea* as per Gates (1974).

Subspecies from Easton (1983) as revised by Blakemore (2004) are:

Ap. rosea bimastoides (Cognetti, 1901). [Types?]. (Sometimes quoted as 1906; syn. *kulagini* Malevics, 1949; *rosea troglodyta* Alvarez, 1971 - sometimes quoted as Sanchez, 1971); also reported from Canaries (Ref.).

Ap. rosea budensis (Szüts, 1909). [Types?]. [Placed in synonymy of *Ap. rosea rosea* by Csuzdi & Zicsi (2003: 92)].

Ap. rosea leocernosvitovi Blakemore, 2004: 78. [Types BMNH 1949:12:12:51-83]. [Nom. nov. pro *Eisenia rosea balcanica* Cernosvitov, 1942: 223 [non *Eisenia veneta balcanica* Cernosvitov, 1937 (= *Dendrobaena* or *Allolobophora balcanica*), nec *Allolobophora balcanica balcanica* Cernosvitov, 1931 (= *Helodrilus balcanicus balcanicus*).

Typical Diagnosis of *Ap. rosea rosea*: Length 25-85 mm. Unpigmented but anterior pinkish, clitellum orange-yellowy and often flared ventrally. Body cylindrical.

Prostomium epilobous. First dorsal pore large in 4/5(/6). Spermathecal pores in 9/10/11 dorsally, or absent. Clitellum 24,25,26-32,33, usually 25-32. Tubercula pubertatis in 29-½31,31 abouts, or rarely on 30 and 31; tumescences around some setae of 9-13, or 15 and 25,26-32,33. Setae closely paired (2aa=bc). Cocoon spherical.

Distribution: Endemic to Holarctic (Caucas, Transcaucasia, Greece and Alps – Gerard. 1964) or to western Palaearctic and Nearctic (Sims & Gerard) e.g. from West Siberia; cosmopolitan in Europe, the Mediterranean, Canaries, Middle East (e.g. many records by Csuzdi & Pavlicek, 2005: 90) and by transportation into North, Central and South America (e.g. Canada, USA, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay), Hawaii, Tristan da Cunha, St Helena, northern Africa (e.g. Morocco, Algeria, Tunisia) and South Africa, India, Asia in China and Korea and from Japan (Hokkaido and eastern Honshu) the Japanese records were thought dubious by Stöp-Bowitz (1969: 190) later confirmed. From Australasia: recorded from New Zealand (Lee, 1959), Chatham Islands (Benham, 1901: 130) and Australia: SA (Barley, 1959a); Victoria (Tisdall, 1985); NSW (Barley & Kleinig, 1964; Wood, 1974) and Tasmania (pers. obs.). Below are the first confirmed records for Tas., Qld. and ACT in Australia.

Locality: Samford, Qld; Scullin and Kippax ACT; Budderoo, Narrabri, NSW; Rocherlea and Invermay, Tasmania; - all new records. Hokkaido specimens also inspected (3 specimens collected by Minamiya 2014/09/11 sent to LBM).

Habitats: Found in most habitats with pH 4.9-9.8, also under stones, logs in pastures, gardens, woodlands, riverbanks and caves. Reported from dry soils (e.g. Ghilarov & Perel, 1984) and from the Negev (eg Csuzdi & Pavlicek, 2005: 90). In the current studies in alluvial soil and pasture beside river and in urban gardens. During the surveys of the Haughley Experimental farm in Suffolk, this species was obtained only from a 1,000 year old permanent pasture and not located in any of the cultivated sections (Blakemore, 2000).

The species *A. rosea* appears to be particularly adaptable since it has been recorded from around the world in a variety of habitats (see Gates, 1972: 104-108) including being found within the Arctic circle under snow in Siberia and widely distributed in Taiga and virgin steppes of Russia; from 0-2,600 m on mountains in Scotland, the Alps, the Caucuses, Kashmir and Himalayas, Hawaii and St Helena; in arid regions from Iran to Morocco and around oases in the Sahara (Ghilarov & Perel', 1984), although reports are less frequent from tropical lowlands.

In South Australia it is very common in pastures. At Samford it was found in relatively high numbers besides the South Pine River and, in observations over a year, appeared to be extending its range slightly and even displacing *Pontoscolex corethrurus* in places (Blakemore, 1994).

Registration No.: Numerous specimens collected by RJB in ANIC.

Behaviour: Fairly docile, but when irritated the anterior becomes blunt almost bulbous and white coelomic fluid is expelled. Found to rapidly emerge onto surface if the soil is scraped (at Samford). Often coils on preservation and exudes much milky mucus from dorsal pores.

Length: 20-110 mm (up to 150 mm for one Hokkaido specimen).

Width: 2-6 mm.

Segments: 100-170.

Colour: Unpigmented but anterior pink-red from blood and posterior dark from soil in gut, clitellum bright orange or yellow or brown.

Prostomium: Open, or closed tapering, epilobous.

First dorsal pore: Very distinct with darkly pigmented auriolae from 4/5 (5/6?).

Setae (7/ratio of aa:ab:bc:cd:dd:U): Closely paired (ca. 10:1:6:1:12:0.3).

Nephropores: Inconspicuous, alternate irregularly above b and d lines.

Clitellum: Saddle-shaped often flared posterior-ventrally, variously from 24,25,26-32,33.

Male pores: Equatorial slits, almost lateral and usually confined to 15 in either large or only slightly raised tumescences, sometimes encroaching in 16 (see Note below).

Female pores: Small and just lateral to b on 14.

Spermathecal pores: Paired in 9/10/11 near dorsal line, or absent.

Genital markings: Tubercula pubertatis usually solid ridges lateral to b lines in 29-½31,31, or "rarer on 30 and 31" (Michaelsen) or "rarely on 30-31" (Lee); Hokkaido specimens had TP in 27,28-31,32; tumescences surround ventral and lateral setal couples of some of 9-13 or 15, and ab only on some of 25,26-32,33, (ab of 12, 13 or 15 modified as genital setae).

Septa: 5/6,6/7-9/10 with some thickening.

Dorsal blood vessel: Single on oesophagus.

Hearts: 6,7-11 progressively increasing in size.

Gizzard: Crop in 15-16, gizzard between 16,17-18,19.

Calciferous glands: In 10 as a large pair of reniform sacs projecting from oesophagus but not sufficiently constricted off therefrom to be called extramural glands (Gates);

opening widely into gut in 10. Sometimes also quoted with pouches in 11-12.

Intestine origin (caeca, typhlosole): Variously taken as either before gizzard in 15 (e.g. Gates, 1972: 105), or afterwards in ca. 20; typhlosole from region of 21-23 complex as shown by Csuzdi & Zicsi (2003: fig. 6.14.2) with four lamellar plates.

Nephridia: Holoic, with U-shaped bladders.

Male organs: Testes/funnels 10 and 11, seminal vesicles 9-12, or lingular in only 11 and 12.

Ovaries: in 13 (small?).

Prostates: None.

Spermathecae: Two small pairs in 9 and 10, spherical ampullae, adiverticulate; sometimes absent.

Gut contents: Fine soil.

Musculature: Longitudinal muscle is of pinnate type Csuzdi & Zicsi (2003: fig. 6.14.1).

Notes: Male pores obliterating intersegmental furrows adjacent to 15 is given as characteristic for *rosea* by Gates (1972) cf. Lee (1959) who has male pores confined to 15 and cf. Martin (1977) who gives either condition, so this character is obviously variable.

Remarks: Biparental reproduction is unknown, seemingly parthenogentic and polyploidy is common; e.g. British populations are basically triploid (chromosome number is 3n=54), but chromosomes numbers of 72, 90, 108, and 160-174 are reported in other populations; the *macedonia* morph from Ashwell, Herts. had a chromosome number of 53 (i.e., 3n-1), (Gerard, 1964: 32).

The more anterior commencement of dorsal pores, as also in some *Eisena*, is a useful character for field separation of specimens of *A. rosea* compared to other species. Specimens of *Ap. rosea* with poorly developed tubercula may be confused with paler specimens of *Eisenia fetida* (also cf. *E. japonica*), yet the gaping dorsal pores, setal ratio 2aa=bc, male pores often encroaching on 16, and septal thickening of 6/7-9/10 are perhaps distinctive for *Ap. rosea*; and, moreover, the lack of the distinctive odour of *E. fetida* can be used to recognize and differentiate these two species.

Genus ***Bimastos*** Moore, 1893

Bimastos Moore, 1893: 333.

[Syns. *Bimastus*: Michaelsen, 1900: 501 (invalid emendation of *Bimastos*); *Spermophorodrilus* Bouché, 1975 (type-species: *S. albanianus* Bouché, 1975 (= *B. antiquus michalisi* Karaman, 1972: 110) from Albania)].

Type-species: *Bimastos palustris* H.F. Moore, 1895: 373 (= *Bimastos* sp. Moore, 1893).

Taxonomic Remarks: Easton's (1983: 477) synonymy had *Spermophorodrilus* Bouché, 1975 [type-species: *S. albanianus* Bouché, 1975 (= *B. antiquus michalisi* Karaman, 1972: 110) from Albania]. *Bimastos* species commonly have spermatophores, and in the latter genus these are supposedly incorporated into the cocoon along with the eggs (Bouché, 1975; Schwert, 1990). The genus *Spermophorodrilus* was again restored from synonymy of *Bimastos* by Omodeo & Rota (1989: 169); its 3 known species are from the Balkans and Anatolia.

Species previously included, but now transferred or returned from *Bimastos* are *Bimastos eiseni* (to *Allolobophoridella* Mrsic, 1990), and *Bimastos tenuis* (as *Dendrodrilus rubidus tenuis*). Easton's (1983: 475) restoration of *Allolobophora parva* Eisen, 1874 seems to have been overlooked or ignored by Sims & Gerard (1985) and Schwert (1990). In the most recent transfer, Csuzdi and Zicsi (2003: 69) argue for its return to the North American genus and place it again as *Bimastos parvus* not least because it has pinnate musculature (cf. fasciculated in *A. eiseni*).

Diagnosis: Male pores on 15 often tumid. Calciferous gland without marked widening in 11-12 opening into the oesophagus in 10 through paired, vertical sacs. Nephridial vesicles U-shaped ducting to bodywall near setal b lines. Nephropores, inconspicuous, alternate irregularly on each side anywhere above setal lines b and d. Hearts 7-11. Dorsal pores from the region of 5/6. Setae closely paired. Prostomium epilobous. Pigment red. Tubercula pubertasis typically absent. Spermatophores often present.

Distribution: About ten North American spp (Blakemore, 2007) of the classical genus are mainly from the unglaciated southeast USA east of the Allegheny Range; but *B. lawrenceae* Fender, 1994 (sometimes misspelt "*lawrencae*") is described from the refugium of Vancouver Island, Canada (see McKey-Fender et al., 1994). Species transferred by Easton's (1983) synonymy of *Spermophorodrilus* were from Albania, Greece, Italy and the Middle East [e.g. *Bimastos samarigerus* (Rosa, 1893) from Jerusalem, and *B. syriacus* (Rosa, 1893) (syn. *atheca*, *atheca kosswigi*) from Asia-minor; these latter are not now in the genus being transferred from *Bimastos* to *Dendrobaena* and to *Healyella*, respectively (see Blakemore, 2004a, 2006, 2007)]. A further Levant species, *Bimastos jordanis* Csuzdi & Pavlicek, 1999 (emdemic to Jordan and Israel) was

transferred to *Healyella jordanis* (Csuzdi & Pavlicek, 1999) as **comb. nov.** by Blakemore (2006/7) [originally included in *Bimastos*, this transfer suggested by Cs. Csuzdi (2003, pers. comm.) – description here]. [Note: genus *Healyella* Omodeo & Rota, 1989 is characterized by male and female pores in setal *ab* lines rather than *bc* as is all other known lumbricids].

Bimastos sophiae Mercandal de Barrio et Barrio, 1988 is **species inquirenda** (originally *Bimastos beddardi sophiae* from Argentina but unlikely to be native, possibly a synonym of *B. parvus* as is *B. beddardi* although Cs. Csuzdi pers. comm. thinks it an athecal form of *A. rosea* and this was published by Csuzdi *et al.*, 2017).

Notes: *Bimastos* spp are often characterized by lack of spermathecae (always?) and lack of Tubercula Pubertatis (TP).

Key to *Bimastos* spp widely distributed in North America (and some elsewhere)

[After Smith, 1917; Gates, 1959; Schwert, 1990: 353; Fender, 1994; Blakemore, 2005].

1a. Clitellum annular on 22,23-27,28, male pore region tumid ..... *Bimastos palustris* Moore, 1895, (often miscited as "*1898*"), the type-species; semi-aquatic from beside rivers and ponds mostly from New England/Carolinas region.

1b. Clitellum annular 21,22,23,-30 … *Bimastos schwerti* Csuzdi & Chang, 2017.

Clitellum saddle-shaped …..... 2

2. Clitellum beginning before segment 26 (and ending before 35) 3

Clitellum on 26,27,28-35,36,37,38 (size ~150 mm, reddish brown with white banding) ... *B. zeteki* (Smith & Gittings, 1915: 545) (see Smith, 1917: 175; Gates, 1956: 35).

3. Clitellum on 20-29,30,31,32, pigment red anteriodorsally ….. *B. giesleri* (Ude, 1895).

Clitellum on 22-29, 30, pigment reddish anteriodorsally ..... *B. tumidus* (Eisen, 1874) (syn. *ducis* Stephenson, 1933); found in about 20 States of USA and in Mexico.

Clitellum on 23,24,25-30,31,32 (23-32,33?) … *B. longicinctus* (Smith & Gittings, 1915) (probable synonym of *B. parvus* but restored by Csuzdi et al., 2017).

Clitellum on 24,25-30; pigment red (anterio-)dorsally ..... *B. parvus* (Eisen, 1874) (syn. ?*beddardi* Michaelsen, 1894; ?*longicinctus* Smith & Gittings, 1915)

Clitellum on 24,25-31, pigment red anteriodorsally ……. *B. beddardi* (Michaelsen, 1894) (?synonym of *B. parvus*).

Clitellum on 25-31,32, pigment reddish dorsally ……. *B. heimburgeri* (Smith, 1928)

Clitellum on 25-34 ..... *B. lawrenceae* Fender, 1994 from near Port Alberni, Vancouver Island British Columbia (known only from 5 specimens).

Clitellum on 25-35, pigment absent …… *B. welchi* (F. Smith 1917: 174) (kown only from holotype collected in 1914 near Manhattan, Kansas).

Cf. *Allolophophoridella eiseni* (clit. 24,25-32,33) or *Dendrodrilus rubidus* (clit. 26-31,32).

Bimastos parvus (Eisen, 1874)

Fig. 6.8 *Bimastos parvus* from Samford, Qld (a) ventral view (b) prostomium.

Allolobophora parva Eisen, 1874: 46. [Locality Mt Lebanon, New York. Types in US National Museum].

Lumbricus (Allolobophora) parvus: Valliant, 1889: 142.

Dendrobaena constricta (part.): Friend, 1893: 19. [Non *Allolobophora constricta* Rosa, 1884: 38 (= *Dendrodrilus rubidus*)].

Allolobophora beddardi Michaelsen, 1894: 182. [Locality Orlando, Orange County, Florida in a rotted tree trunk. Type Hamburg, 153]. [Non *A. beddardi* Ribaucourt, 1896 (= *Ap. caliginosa/trapezoides* complex)].

Allolobophora parva udei Ribaucourt, 1896: 80. [Locality Heustrich, Switzerland. Types? Note: Michaelsen (1900: 477) placed this taxon in *Eisenia* but it is now in synonymy of *B. parvus*].

Allolobophora consticta var. *geminata* Friend, 1897: 549. [From Co. Antrim, Northern Ireland. Types?]. [Often misspelt "germinata"].

Helodrilus (*Bimastus*) *parvus* : Michaelsen, 1900: 502 [part., cf. *Allolobophora parva udei* that Michaelsen (1900: 477) placed in *Eisenia*]; *parvus* + *beddardi* + *longicinctus* : Smith, 1917: 173, 174.

Helodrilus (*Bimastus*) *beddardi* : Michaelsen, 1900: 502 (syn. *constricta* var. *geminata*).

?Helodrilus longicinctus F. Smith & Gittings, 1915: 548. [Locality southeast USA. Types in US National Museum 24597-8].

Bimastos longicinctus : Gates, 1985; Schwert, 1990: 353.

Eisenia parva: Pop, 1949: 89, 123 [misidenfication of *A. eiseni* according to Csuzdi & Zicsi, 2003: 70]; Bouché, 1972: 386; Zicsi, 1982: 436.

Bimastos parvus: Gates, 1956: 6; 1972: 87 (syn. *beddardi*; ?*longicinctus*); Reynolds, 1977: 61, fig. 16 [syn. *constricta* (part.); *constricta germinata* (part.); *beddardi*]; Easton, 1981: 41 (syn. *beddardi*); Sims & Gerard, 1985, 1999: 48; Schwert, 1990: 353; Csuzdi & Zicsi, 2003: 69, 71; Blakemore, 2003, 2005, 2007, 2008.

Bimastus parvus (Eisen)?: (sic) Yamaguchi, 1958: 110, text-fig. 20 (from Hokkaido).

Allolobophora parva: Easton, 1983: 475 (syn. *beddardi* Michaelsen, 1894; *parva udei* Ribaucourt, 1896; *constricta geminata* Friend, 1897); Perel, 1979: 18.

Allolobophoridella parva: Mršić, 1991.

Taxonomic Notes: Gates (1985) enigmatically reversed his earlier (1972) synonymy and listed *parvus*, *beddardi* and *longicinctus* separately in *Bimastos* (although he also listed the *gieseleri* Ude, 1895 synonym of *B. tumidus* Eisen, 1874 separately). Easton (1983) appears to have rejected or ignored the synonymy in *B. parvus* by Gates (1972) of *Bimastos longicinctus* Smith & Gittings, 1915, rather he provisionally retains it in *Eisenia* although it was excluded from *Eisenia* by Perel' (1974) but without reallocation to a preferred genus. Easton (1983) also transferred *constricta* to synonymy of *Dendrodrilus rubidus rubidus*. Levinsen's *eiseni*, at times included in *A. parva* due to misidentification, is now in *Allolobophoridella*. Easton (1983) said *Allolobophora parva* Eisen, 1874 replaces *Eisenia parva* or *Bimastos parvus*, but current workers still use one or other of these names and, most recently, this taxon was briefly transferred to the genus *Allolobophoridella* Mršić, 1990 before its return to *Bimastos* by Csuzdi & Zicsi (2003: 69, 71). A *species inquirenda* is *Bimastos sophiae* Mercandal de Barrio et Barrio, 1988: 2 [originally *Bimastos beddardi sophiae*] from Argentina that is unlikely to be native, possibly a synonym of *B. parvus* as is *B. beddardi*.

Diagnosis: Length 17-85 mm. Body cylindrical. Pigmented, reddish above, yellowish below. Prostomium epilobous. First dorsal pore 4/5/6. Spermathecae absent. Clitellum (22?),23,24,25,26-30,31,32,(33?), usually 24-30. Tubercula pubertatis absent or edging clitellum in 24,25,26-30 or 28-29,30. Setae closely paired (ab=cd, aa>bc, dd=0.5U).

Distribution: (Mainly from Michaelsen, 1900; Gates, 1956: 6, 1972; Easton, 1981 and pers. obs.), endemic to North America but often translocated there e.g Minnesota (reported most often as *beddardi*, cf. *parvus* that has only one record from Yukon Territory, Canada), Hawaii (*beddardi*), Central and South America [e.g. Mexico (including its presence in fishing bait soil), Venezuela, Guatemala, Brazil, Argentina, Costa Rica], Iceland, Europe including British Isles [although not accepted from UK by Sims & Gerard (1999), *beddardi* was recorded from Ireland by Michaelsen (1900: 502) probably from Friend's (1897) *A. constricata var. geminata* report, and *parvus* by interception at American ports was from England and Wales (Gates, 1956: 7 and Gates, 1972: 87) thus the British record stands], France (only two reports of *parvus*), Russia, Siberia, Afghanistan, Kazahkstan and Central Asia, South Africa, Mauritius, St Helena,

St Paul (Indian Ocean), Tahiti, Hawaii, Himalayas, Pakistan [as recently reported from Kamra in Attock District by Ghafoor (2003)], Tibet at nearly 4,000m (Michaelsen, 1903: 50, 141 as both "*Beddardi*" and *parva*, the only lumbricid recorded from that country), South India (e.g. Darjiling), reported from Vietnam, Malaysia [e.g. recorded from Cameron Highlands by Gates (1938: 222)], Myanmar, China, (Manchuria), Korea, all of Japan, Taiwan [by interception from Gates (1972: 87) and by survey Kobayashi (1938), also identified from Taiwan by the current author], Java, Australia. [The record for New Zealand in Sims & Gerard (1985) is unverified as I can find no such report (cf. *D. rubidus tenuis* and *A. eiseni*) although there are several native taxa with the species name "*parva*" or "*parvus*" (see Lee, 1959)]. The previous Australian record is a single specimen found by Michaelsen (1907) in WA. The current reports of this species in Qld and NSW are new records for Australia. Michaelsen (1903: 141) reported it from northeast Mongolia (Sud-zil-gola) and Tibet (origin of the Mekong) as its *H. beddardi* synonym. Okinawa is a **new record** from collectors RJB + MN, 16-II-16 from under rocks at Gushikawa Castle, Kumejima found with *Pithemera bicincta* (specimens deposited in Biwako Museum, LBM FY2015-11)) although Kobayashi (1941) reports it from "海士村" that I translate as Ama mura, possibly on Nakanoshima in Oki, Shimane Ken.

Locality: Samford and Brookfield, Qld., other samples from NSW; Japanese specimens also found by the author (26.V.2003) under plant pots in carpark of hotel in Okutama, north of Tokyo (samples sent to Cs. Csuzdi for molecular comparison); from Kamakura (June, 2004), Tanzawa mountains (April, 2005), from Lake Biwa Museum grounds (2010), from soily compost heap on campus of Shiga-ken University, Hikone, from paddy embankment at Azuchi-cho, Dainaka, Omihachiman-shi, and from Shingu jinja gardens [all these latter Shiga-ken specimens collected by RJB now in Lake Biwa Museum (LBM FY2015-11) collection]. Also from Jianshi Shiang, Hsinchu County, Taiwan (NTU 25.III.2003 – pers. obs.); and 16.II.2016 from Gushikawa Castle, Kumejima, Okinawa.

Habitat: Soil with pH 7.5 wetted by effluents; wooded areas; gardens; fields; under logs; in compost and potting mix; caves (Gates, 1972). Boettcher & Kalisz (1991) found this species, which they characterize as being adapted to inhospitable sites, under rhododendrons in Kentucky. In current studies found in alluvial pasture and under litter in red podzolic soil or more usually in habitats of high organic matter. Under plant pots

in carpark in Okutama, Japan (26.v.2003, RJB) and from drain at Kuzuharagaoka Shrine, Kamakura, Japan (one mature collected 13.vi.2004 by RJB, Amanda Reid and Yuko Hiramoto); carpark, compost heap, rice paddy and shrine gardens in Shiga-ken Japan (2010 and 2011). Under rock at Kumejima, Okinawa (pers. obs. in 2016).

Registration No.: Specimens collected by RJB in ANIC and YNU, also in LBM.

Behaviour: Fairly docile; coils on preservation.

Length: Range, 17-85; current adult specimens c. 30-35 mm.

Width: c. 1.8-3 mm.

Segments: 66-124, with deep furrows; body circular becoming slightly octahedral posteriorly.

Colour: Dorsum, dark to light red-brown with slight iridescence, ventrum pale, clitellum buff; tip of tail sometimes has yellow inclusions.

Prostomium: Widely open epilobous.

First dorsal pore: (4/5)5/6 indistinct.

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment from 2, fairly closely paired; setae b of 14 dehisced or absorbed in one specimen seen by author; (ca. 5:1:3:1:4:0.25).

Nephropores: Irregularly from lateral to b (in front and through clitellum) to above d (e.g. in 7/8/9/10).

Clitellum: Saddle-shaped, usually 24-30; range (22?),23,24,25,26-30,31,32,33; (25-31,½32 in *beddardi*).

Male pores: Lateral slits adjacent to b and confined to 15, with paler tumid lips that intrude on (14/15 and) 15/16.

Female pores: Small slits from position of (missing) b on 14.

Spermathecal pores: Absent (present in *beddardi*).

Genital markings: None; occasionally seen on edge of clitellum on 24 or any of 26,27-28,29,30, (e.g. 26-30 in *beddardi* overlying the ventral pairs of setae), perhaps most often as tumescence ventrally in 30 (as in *beddardi*). Papillae other than those of 30 not known around setae.

Septa: Equally thin to 16/17 then become reduced.

Dorsal blood vessel: Single.

Hearts: 7,8 weak, 9-11 strong, weak extra-oesophageals to dorsal vessel in 12.

Gizzard: Crop or proventriculus precedes gizzard which is muscular, enveloped in capillaries and occupies 16-18.

Calciferous glands: Supposedly without marked widening in 11-12 opening into gut in

10 through paired lateral sacs; sometimes obscured by seminal vesicles in 11 and 12.

Intestine origin (caeca, typhlosole): 19; (typhlosole deep lamelliform).

Nephridia: Holoic with large elongate bladders (stated to be U-shaped in some accounts) which duct to parietes near setal b lines internally.

Male organs: Testes/funnels 10 and 11 (posterior pair reduced) as large, free iridescent sheets beside gut and attached to septa, funnels also iridescent; large seminal vesicles appear to surround gut in 10-12 (usual location given as small in 11 and 12).

Ovaries: Strings of large eggs, palmate in 13.

Prostates: None.

Spermathecae: Athecate (always?); small transparent sacs seen in 10 and 11 possibly spermathecae (two pairs of dorsal spermathecae present in 7 and 8 in *beddardi*).

Gut contents: Fine soil and organic matter.

Notes: In the current study, only a few specimens were found in Australia, Japan and Taiwan; in Queensland they were in association with several other species including the similarly small-sized *Drawida barwelli* and *Amynthas minimus*. Temirov & Valiachmedov (1988) introduced what they considered to be this species in irrigated desert soils of Tajikistan and found it to be most beneficial: barley yields were increased six fold.

Remarks: According to Gates (1972) "Bimastos parvus *is not a species but an aggregate of parthenogenetic morphs or clones*". The above description is for apparently fertile specimens and concurs with that of Chen (1933), but differs in several respects, particularly with reference to reproductive organs, compared to Gates' (1972) unusually curt definition of his male sterile morphs.

While returning *B. parvus* to *Allolobophora* Easton (1983) lists *B. beddardi, B. parva udei* and *B. constricta geminata* in the synonymy; however he seemingly rejected synonymy of *Bimastos longicincta* Smith & Gittings, 1915. Earlier, Gates (1972: 86,88) only tentatively included under *Bimastos parvus* the names ***beddardi*** and ***longicinctus*** which had hitherto been distinguished by their clitellar ranges: (23),24,25-31,32 and 23,24-32,33, respectively. The distribution range above may include records of all three names. Their small somatic size probably accounts for infrequent collection and/or identification and they may easily be confused with *Dendrobaena* spp. or to *Eiseniella tetraedra* (op. cit.) that may have male pores on 15 too although its female pores median to setae a seem to be characteristic.

Regarding the *longicistis* synonymy, Gates (1972: 86, 88) combined *beddardi*

and *longicincus* under *parvus* saying all three taxa "*intergrade without known ways of delimiting each from the others*". Dr Sam James (pers. comm. email 8th December, 2004) made these comments:

> "*I have Gates' unpublished notes on* Bimastos*, as well as lots of* Bimastos *in my own collection. In Gates' notes he made a key, the first couplet of which says, 40-45 partitions in calciferous glands, vs. 60-64.* B. parvus *has the fewer, and* longicinctus *(and* B. zeteki*) has the greater. I have used this character and it works, though it is a bit tedious.* B. longicinctus *is one of the few species in its genus that I have ever found outside of forests (it does both forest and grassland).* B. parvus *as a peregrine turns up in a variety of places, and* B. welchi *has a natural nearly totally non-forest distribution. Thus I think it is safe and appropriate to delete mention of* B. longicinctus *as a potential synonym of* B. parvus*, unless it is to correct the earlier misconception of it as a junior syn.*".

However, in fact, Gates had previously publish his notes to this effect (Gates, 1956: 6) following Smith (1917: 175) but he also stated there to be an unknown variation. (Cf. the acceptable wide variation in the number of partitions in the calciferous glands in *A. rosea* he quotes on the same page as "*38-54*"). Thus, to me, this difference in calciferous glands seems rather to imply that when in a North American grassland habitat, specimens of *B. parvus* having more partitions in their calciferous glands are more common and thus, if this is the only tenuous difference, the synonymy above stands.

Recently, I collected specimens from Ullong-do Island in Korea that had superficial characteristics of both the *parvus* and *beddardi* forms.

Bimastos tumidus (Eisen, 1874)

Allolobophora tumida Eisen, 1874: 45, tab. 2, fig. 5-8. [Mt Lebanon, NY/Massachusetts. Type reported missing by Reynolds & Cook (1976) but Gates (1956: 1) says "*one half of anterior end sagittally sectioned by Smith, in U. S. Nat. Mus*."].

Lumbricus (Allo[*lo*]*bophora*) *tumidus* : Vaillant, 1889: 140.

Allolobophora gieseleri Ude, 1895: 339. [Savannah, Georgia. Types, numerous, in Hanover Provincial Mus.?].

Allolohophora (*Bimastus*) *tumida* : Michaelsen, 1900a: 10.

Helodrilus (*Bimastus*) *tumidus* : Michaelsen, 1900: 502.

?*Helodrilus* (*Bimastus*) *gieseleri* var. *hempeli* Smith, 1915: 551; 1917: 172. [Type locality, Havana, Illinois. Types in US Nat. Mus.].

Helodrilus (*Bimastus*) *tumidus* + *gieseleri* var. *typica*: Smith, 1917: 170.

Bimastos ducis Stephenson, 1933: 939. [Durham, North Carolina. Type BMNH 1932:6:24:42].

Bimastos tumidus : Gates, 1956: 1 (syn. *gieseleri* Ude, 1895; *gieseleri hempeli* Smith, 1915 (sometimes misspelt "giesseleri") – syn. not accepted by all subsequent authors; *ducis* Stephenson, 1933); Schwert, 1990: 353.

Notes: *Bimastos ducis* Stephenson, 1933 is usually in synonymy although James (1995: 34) apparently attempts to maintain it. Both *Bimastos giessleri* (Ude, 1895) and *Bimastos giesseleri hempeli* (Smith, 1915) have in the past been put in synonymy; these two taxa are rather similar to genus (in France only?) *Prosellodrilus* Bouché 1972 (see Baha & Bera, 2001 for examples and discussion on this genus - Ref.).

Extended Diagnosis: Length, 26-40 mm. Diameter, 2-3.5 mm. Segments, 40-50 (Michaelsen) or 81-122 (Gates). Setae closely paired. Body red dorsally, quadrangular posteriorly with one setal couple at each corner. Prostomium epilobous, open. First dorsal pore 5/6. Male pore tumescences on 15 sometimes dislocating 14/15 and 15/16 slightly. Clitellum saddle-shaped, 22-29 (Michaelsen) or 20,21,22-29,30 (Michaelsen including *gieseleri* and Gates). Tubercula pubertatis paired and slightly raised on 27 and 28 (Michaelsen) or lacking (*gieseleri* and Gates). Genital tumescences around setae lacking or unrecognizable.

No septa thickly muscular (or 6/7-14/15 slightly). Calciferous gland extends well into 10-11,12. Intestinal origin in 15. Gizzard in 17-18. Typhlosole begins gradually in 21. Hearts present in 7-11. Nephridial ducts, at least behind 15, pass into parietes at b. Vesicles U-shaped. Seminal vesicles small paired in 11 and 12. No spermathecae.

Distribution: widespread in USA [e.g. NY, North Carolina, California, New Orleans, Louisiana (under logs in moist river bottom forest and in and near ash of sawdust pile), Texas, Virginia, Missouri (Olsen, 1936), Gates, 1956: 1, etc.] and introduced to Mexico (Fragoso , pers. comm. and Fragoso & Brown, 2007: 70). It can become established in compost heaps and survive in cold mid-western States such as Iowa.

Genus ***Dendrobaena*** Eisen, 1874.

Dendrobaena Eisen, 1874: 53. [Sometimes dated "1873"].

[Syn. *Omodeoia* Kvavadze, 1993: 132 [type-species *D. byblica* (Rosa, 1892)] (syn.

from Csuzdi & Zicsi, 2003: 107); but restoration mooted in species description below].

Type-species: *Dendrobaena Boeckii* Eisen, 1873/4 (= *Enterion octaedrum* Savigny, 1826).

Taxonomic Notes: The generic definition, based on that of Sims & Gerard, is unsatisfactory following Easton's (1983) transfer of the closely-related *hortensis* and *veneta* into this genus, although removal of these two taxa from *Eisenia* is probably justified. In some generic diagnoses [e.g. Gates (1972: 88, 91); Reynolds (1977: 64)] hearts are stated to be in "*vii-ix*", rather than the usual 7-11 but this perhaps restricted to parthenogenetic morphs or, more likely, a typing error not uncommon when Roman numerals are used. Rota & Erseus (1997: 79, tab. 3) show last hearts in any of 9-11.

Diagnosis: Setae fairly widely paired or distant. Calciferous gland moniliform in 10,11-12 opens directly into the oesophagus in 11 or near 10/11. Nephridial vesicles variously ocarina-shaped or J-shaped [e.g. in *attemsi*] or sausage-shaped [e.g. in *hortensis*, *octaedra* (?), and *veneta*] ducting to bodywall ventrally (and/or laterally). Nephropores obvious in single row along each side of the body above b lines or alternating above b and d lines (e.g. in *hortensis* and *veneta*). Hearts 7-9,10,11. Prostomium proepi- to tanylobous. Pigment red. Dorsal pores from the region of 4/5/6. Setae separate or widely paired (e.g. in *hortensis* and *veneta*).

Distribution: Palaearctic to Middle East and Levant [e.g. *Dendrobaena byblica* (Rosa, 1893) species-complex]. The genus contains about 55 species, only a few of which are widely distributed by transportation.

Remarks: Species previously included but now transferred from *Dendrobaena* are *D. mammalis* (= *Satchellius mammalis*) and monotypic *Dendrodrilus rubidus* which has also collected further subspecies from *Bimastos*. The taxa *hortensis* and *veneta* were returned to *Dendrobaena* by Easton (1983), where at least their widely paired setae resemble the those in the type-species, from their previous awkward placement in *Eisenia* (e.g. by Sims & Gerard, 1985). Taxa *hortensis* and *veneta* were sometimes combined at the sub-species level (i.e., potentially interbreeding populations). D. *madeirensis* (Michaelsen, 1891) was retained in *Allolobophora* by Easton (1983).

Closest relationships of *Dendrobaen pygmaea* (Savigny, 1826: 183) are probably with *D. octaedra* (Savigny, 1826: 183) and *D. attemsi* (Michaelsen, 1903) that together probably form a highly polymorphic parthenogenic species-complex, as mooted by Gates (1972: 92) who also thought that *D. mariupoliensis* Wyssotsky, 1898 (now = *D. nassonovi* Kulagin, 1889), *D. samarigera* (Rosa, 1893) (sometimes placed in *Bimastos*

or belonging in some other genus together with *D. hauseri* both from the Levant), and some of the *D. byblica* (Rosa, 1893) species-complex may also belong in this grouping. Csuzdi (pers. comm.) thinks that *D. mrazeki* (Cernosvitov, 1935) is morphologically closer to *D. pygmaea*, apart from its larger size. Moreover, if *Satchellius mammalis* (Savigny, 1826:181) is implicated, then either *octaedra* and *pygmaea* compete for page priority, or else the name *mammalis* takes precedence overall. As stated by Csuzdi & Pavlicek (1999: 473) "*The genus* Dendrobaena *is heterogeneous and urgently needs revision*".

Rota & Erseus (1997: 79, tab. 3) characterize some species. Csuzdi *et al.* (2017: fig. 1) has *D. byblica* DNA separate from other genus members flagging some problem.

Key to the Peregrine Species of *Dendrobaena*

SP = Spermathecal pores; TP = Tubercula pubertatis.

1. TP on segments 30 and 31 only; SP dorsally in 9/10/11 …… 2
   TP not just in 30-31, or absent ……..……..… 3
   TP 25-29,30; SP 9/10/11 in or above d lines …..…..… *D. byblica* spp-complex
2. Length >50mm; pigment often banded ……..…. *D. veneta* (Rosa, 1886)
   Length <50mm; pigment more uniform …..... *D. hortensis* (Michaelsen, 1890)
3. TP after 34 or absent; SP dorsally in 9/10/11/12 or absent… *D. pygmaea* (Savigny, 1826)
   TP between 30-33; SP in d lines ……. 4
4. TP on segments 30-32,½33; SP in 9/10/11 in d ….. *D. attemsi* (Michaelsen, 1903)
   TP on segments 31-33; SP in 9/10/11/12 …… *D. octaedra* (Savigny, 1826)

D. hortensis and *D. veneta* characters are tabulated in Briones *et al.* (2009: Tab. 3).

Dendrobaena attemsi attemsi (Michaelsen, 1903) distribution

Fig. 6.9.1. *D. attemsi* from Mt Wellington, Auckland. Cf. Fig. from Sims & Gerard (1999: fig. 20) that may easily be confused with other taxa by non-specialist novices who use that book, such as with *A. caliginosa* when segments are miscounted by just one.

Fig. 6.9.2. Distribution of *D. attemsi.*

Helodrilus (*Dendrobaena*) *Attemsi* Michaelsen, 1903: 47. [From Styer, Strassengeler

Forest by Graz, Austria. Types in Hamburg V5827 (Cs. Csuzdi, pers comm) but stated as missing by Reynolds & Cook, (1976: 73) who apparently also mislist it as "*Haplotaxis attemsi* Mich., 1903: 47"].

Dendrobaena apora Qiu & Bouche, 1998: 156.

Dendrobaena attemsi: Bouché, 1972: 393; Gates, 1972: 92; Gates, 1974: 54; Fender, 1982: 8; Sims & Gerard, 1985, 1999: 68, fig. 20; Rota & Erseus, 1997: 89, fig. 2; Blakemore, 2002, 2008 2010; Szederjesi & Csuzdi, 2012: 264 (syn. *apora*).

Dendrobaena attemsi attemsi: Easton, 1983: 478; Blakemore, 2004a; 2007.

Taxonomic Notes: Note often misattributed at "Michaelsen, 1902" (e.g. by Rota & Erseus, 1997) although the original publication clearly states "**Issued in 1903**" - http://www.archive.org/stream/mitteilungenausd19natu#page/n8/mode/1up.

Easton (1983) and Blakemore (2004) list the other subspecies as ***D. attemsi decipiens*** (Michaelsen, 1910) [originally *Helodrilus (Dendrobaena/Eisenia) alpinus* var. *decipiens*; with types unknown] that has spermathecal pores closer to mid-dorsal line plus irregularly alternating nephropores and last hearts in 11. It is sometimes given separate species status (e.g. Omodeo & Rota, 1989) who also in their Table 3 summarize similar species they call presumed phylogenetic neighbours.

A comment by Gates (1972: 92) that Turkish worms recorded as *D. attemsi* but with spermathecal pores in 10/11/12 are more likely to have arisen by the deletion of the anterior pair from *D. octaedra* than by a posterior transfer of those of *D. attemsi* from the more usual 9/10/11 cf. recorded from Turkey by Rota & Erseus (1989 according to Rota & Erseus, 1997), and these latter authors also note Pop (1947) thought these two specimens were syonymous perhaps leading to Gates' statements above.

Diagnosis: Length 26-70 mm. Pigmented, rosy to dark red with a characteristic, opaque area over 9-11,12. Prostomium epilobous (sometimes appears tanyobous). First dorsal pore 4/5-7/8 or further back. Spermathecal pores in 9/10/11 in d lines. Clitellum 28,29-34. Tubercula pubertatis narrow ridges in 30-32 lateral of b.

Distribution: Russia, Sweden [two reports from National Park near Stockholm (Rota & Erseus, 1997, Ref.1) and Shore of Säveån (Ref.2)], Denmark (CABI website – Ref. 2012), the Czech and Slovak republics, the Ukrainian and Rumanian Carpathians, Austria, Balkans e.g. Serbia (Ref.), Albania (Szederjesi & Csuzdi, 2012: 264), Germany, Belgium, France, northern Greece and Turkey, glasshouse in Hungary (Csuzdi *et al.*, 2008) and the Caucasus Mountains (Rota & Erseus, 1997); introduced into USA [in a greenhouse in Oregon (Fender, 1982: 8)], Canada, Vancouver Island (Marshall & Fender,

2007), northwest Spain (e.g., Monroy *et al.* 2003), UK (a single record from Cark, Cumbria plus more abundant in southern woodlands according to Natural History Museum website) and Ireland (Cotton, 1992, and confirmed by RJB in material from Dublin, pers. obs.). Mostly it is a rare species. Unverified reports from almost each State in Australia are a misidentification possibly of *D. rubidus* or some other taxon, such as *A. caliginosa*, by a non-specialist (as noted by Blakemore, 1999 and now proven since the original claimant, 10yrs later, failed to defend its claim – Ref.). **New Australasian reports:** From near Taupo and from Auckland, NZ are by Blakemore (2011, 2012. – see Locality below) and a new record is from near Paratunka town, Kamchatka in a compost heap near greenhouses by Shekhovtsov *et al.* (2014). A recent (2015) report of "*D. cf. attemsi*" from southwestern Western Australia is now confirmed.

Locality: Actual species only confirmed from Australia recently in WA after my discovery from NZ: from Golden Springs Holiday Camp ground at Mihi near Taupo in the Broadlands district from beside tepid creek feeding into Waiotapu creek in landscaped gardens that had bamboo and exotic and native plants (coll. RJB, 11th Sept., 2011); also from Mt Wellington, Auckland from rich meadow soil on slope (coll. RJB, 14th Oct., 2011); one Golden Springs specimen in Auckland Museum (AMNZ 5258 – DNA RJB06) and one unregistered in AMNZ (to be sent to interested colleagues – DNA RJB08); and Mt Wellington, Auckland specimen AMNZ2569 (RJB16).

Habitat: Very acid situations (pH 3.5-5.6) in sandy and peaty soils, in woodland under moss and logs and in litter; in a greenhouse potting mix containing sphagnum peat (Sims & Gerard, 1999: 68); compost (Shekhovtsov *et al.*, 2014); from Taupo, NZ beside warm stream under bamboo and other exotic and native plants, and from pasture of scoria cone of Mt Wellington, Auckland.

Behaviour: Fairly docile.

Length: 22 (Michaelsen) -70 mm (current NZ specimens 40-45 mm).

Width: 1-3 mm.

Segments: 69-77 (current specimens without tail regeneration) or 85-151 (other authors).

Colour: Rosy to puce or dark red anterior and dorsum with whitish area over 8,9-11,12 obvious ventro- laterally; pale ventrum and clitellum white or buff.

Prostomium: Open epilobous but (pers. obs.) may be faintly closed or sometimes appearing tanylobous.

First dorsal pore: 4/5-7/8 indistinct, often indeterminate until after 13/14 or 14/15 and then ephemeral and only barely visible (pers. obs.), or after 26/27 in Turkish specimens

(Rota & Earseus, 1997). [Cf. *D. octaedra* were they are surely more obvious].

Setae (ratio of aa:ab:bc:cd:dd:U): Widely paired from 2; (1:1:1:1:2:?); setae b on 14 & 15 (pers. obs.) or 15 & 16 and sometimes around ab on some other segments (e.g. 24-26, or 30-33) on in round tumescences (see Rota & Erseus, 1997 tab.1 for variabilities).

Nephropores: Single row (above b lines) reported; although Rota & Erseus (1997: 92) say they alternate regularly between b and d lines with those in d small and difficult to find with which I concur – b setal alternation is especially obvious ventrally in 15-35.

Clitellum: Saddle-shaped, 28,29-34 slightly more extensive dorsally.

Male pores: Slits lateral to b and confined to 15 but wide and, characeristically, visible from the dorsum; paler tumid lips just intrude on 15/16.

Female pores: Small slits lateral to b on 14 (confimation).

Spermathecal pores: 9/10/11 in d lines (minute, confirmation).

Genital markings: What Gates (1974) called "blister organs" are circular cushions in cd in ½8,9-11,½T12. Tubercula pubertatis ridges on 30-32, ½33 lateral to b.

Septa: Thin.

Dorsal blood vessel: Single?

Hearts: 7,8,-10 [Rota & Erseus (1997: 97) have last hearts in "*ix or x*" and say "*hearts are always missing in xi*" and "*can be absent in x as well (Table 1)*"]; dissected NZ specimen also appeared to lack hearts in 11.

Gizzard: 17.

Calciferous glands: Calciferous glands small compact, white and moniliform in 11-12 (confirmed).

Intestine origin (caeca, typhlosole): ?

Nephridia: Holoic with ocarina-shaped bladders ducting to parietes near b lines (even those exiting in d lines); or bladders slenderly J-shaped according to Rota & Erseus (1997: 92) but this questioned by Cs. Csuzdi (pers. comm.).

Male organs: Testes/funnels holandric; seminal vesicles 9-12 (Sims & Gerard, 1999) or 9,11-12 (Rota & Erseus, 1997), although they appeared most developed in 11 & 12 in NZ specimen. Testis irridescent in 10 and 11.

Ovaries: In 13 tightly bunched.

Prostates: None.

Spermathecae: Two pairs on stalks with the terminal bulb irridescent (NZ specimen).

Spermatophores: Reported near male pores by Sims & Gerard (1999: 68) but if so then this seems additional to or non compatible with functioning spermathecae.

Gut contents: Organic soil in specimen dissected.

Remarks: Records of *D. attemsi* in Oregon, the Atlantic coast of Europe, Siberia and now NZ, show this species is subject to infrequent transportation but its small size means it may have often been overlooked, cf. several mistaken identifications from Australia.

DNA

Note: Genbank FJ214224 "*Dendrobaena attemsi*" from "USA: Olympic National Forest, Washington" is a misidentification for *Dendrobaena octaedra*! I confirm this misidentification is only 527/651 (81%) with my New Zealand *D. attemsi* below (from Blakemore, 2012) and my DNA ID now confirmed by Shekhovtsov *et al.* (2014).

>RJB06_*D. attemsi* Golden Springs, NZ. [BLAST Sept., 2017 = 99-100% *D. attemsi* from Kamkatcha and from Australia: Western Australia, Fremantle, Prison Heritage Cottages].
AACCTTGTACTTCATCTTAGGAATTTGGGCCGGTATAGTGGGAGCAGGTATAAGTTTACT
AATTCGAATCGAATTAAGCCAGCCTGGAGCCTTCCTAGGAAGAGATCAACTATACAATA
CTATTGTCACAGCTCATGCTTTTGTAATAATTTTCTTTCTAGTAATACCAGTATTTATTGG
GGGATTTGGAAACTGGCTATTACCTCTTATATTAGGAGCCCCTGATATAGCATTTCCTCG
ACTAAATAATATAAGATTTTGACTACTGCCCCCCTCTCTAATCCTACTTGTCTCTTCTGCA
GCTGTAGAAAAAGGAGCAGGAACTGGATGAACAGTGTATCCTCCCTTAGCAAGAAAC
CTAGCACATGCTGGTCCCTCAGTAGATCTAGCAATCTTTTCTCTACATCTAGCAGGAGCA
TCCTCAATTCTTGGAGCTATCAACTTTATTACCACTGTAATCAACATACGATGAACAGGT
TTACGTCTAGAACGAATCCCACTATTTGTATGGGCTGTAGTGATCACTGTAATTCTTCTT
CTATTATCCCTGCCTGTACTTGCAGGAGCTATTACAATACTTCTTACAGACCGAAATCTA
AATACATCATTCTTCGACCCAGCCGGGGGGGGAGATCCAATTCTATACCAACACTTATT
C

>RJB08_D. attemsi Mt Wellington, NZ. [BLAST comparison 100% RJB06].
AACCTTGTACTTCATCTTAGGAATTTGGGCCGGTATAGTGGGAGCAGGTATAAGTTTACT
AATTCGAATCGAATTAAGCCAGCCTGGAGCCTTCCTAGGAAGAGATCAACTATACAATA
CTATTGTCACAGCTCATGCTTTTGTAATAATTTTCTTTCTAGTAATACCAGTATTTATTGG
GGGATTTGGAAACTGGCTATTACCTCTTATATTAGGAGCCCCTGATATAGCATTTCCTCG
ACTAAATAATATAAGATTTTGACTACTGCCCCCCTCTCTAATCCTACTTGTCTCTTCTGCA
GCTGTAGAAAAAGGAGCAGGAACTGGATGAACAGTGTATCCTCCCTTAGCAAGAAAC
CTAGCACATGCTGGTCCCTCAGTAGATCTAGCAATCTTTTCTCTACATCTAGCAGGAGCA
TCCTCAATTCTTGGAGCTATCAACTTTATTACCACTGTAATCAACATACGATGAACAGGT
TTACGTCTAGAACGAATCCCACTATTTGTATGGGCTGTAGTGATCACTGTAATTCTTCTT
CTATTATCCCTGCCTGTACTTGCAGGAGCTATTACAATACTTCTTACAGACCGAAATCTA
AATACATCATTCTTCGACCCAGCCGGGGGGGGAGATCCAATTCTATACCAACACTTATT
C

Dendrobaena byblica (Rosa, 1893) species-complex

Included species, at least, are:

Allolobophora (Dendrobaena) byblica Rosa, 1893; 4. [Types Turin 463].

Helodrilus (Dendrobaena) byblicus: Michaelsen, 1900: 492.

Omodeoia byblica : Kvavadze, 1993.

Allolobophora fedschenkoi Michaelsen, 1900a: 7; 1900: 492. [From Turkestan. Types?]. [Sometimes in synonymy or separated off; sometimes misspelt "fedtschenkoi"].

Helodrilus (Dendrobaena) lacustris Stephenson, 1913: 55. [Types Calcutta 5363 and BMNH 1913:2:17:1].

Diagnosis of group: Clitellum 24,25-30; TP 25,26-28,29. Setae widely paired; ab on 10 and/or 11 on papillae. Spermathecae 9/10/11 in d lines. Length 20-65mm; width 3-5mm; segments 80-130.

Distribution: One of most widely distributed groups in the circum-Mediterranean and Middle-east and Asia-minor regions. *D. byblica* is also recently reported from Tenerife Canaries [e.g. Ref.1, Ref.2 and Ref.3], northern Iran (Ref.) and Uzbekistan (Ref.).

Remarks: Taxa in this group have been described under >20 names by various authors (Gates, 1979) and, as stated by Csuzdi & Pavlicek (1999: 474), this species-complex is in most urgent need of revision. Csuzdi *et al.* (2017: fig. 1) has *D. byblica* DNA separate from other genus members flagging some problem that possibly requires restoration e.g. re-separation off in *Omodeoia* Kvavadze, 1993: 132 [type-species *D. byblica* (Rosa, 1892)]. Only this representative taxon is briefly considered here:

Dendrodrobaena byblica byblica (Rosa, 1893) [syns. - mostly from Michaelsen (1900); Csuzdi (2003) and Blakemore (2007):- *ganglbaueri annectens* Rosa, 1895 with male pores on 25 (restored or claimed as *Fitzingeria annectens* (Rosa, 1895) by Qiu & Bouché, 1998: 198); *fedschenkoi* Michaelsen, 1900; *ganglbaueri olympiacus* Michaelsen, 1903; *thyrrenus* Baldasseroni, 1907; *ganglbaueri daghestanensis* Michaelsen, 1907 (sometimes dated as 1910); *schelkovnikovi* Michaelsen, 1907 [misdated "1900" and cited in *Omodeoia* by BIOSIS; retained as a valid species by Kvavadze & Nikilaishvili (1980), also placed as a sub-species of *D. surbiensis* by some authors]; *ganglbaueri meledaensis* Michaelsen, 1908; *schelkovnikovi veliensis* Michaelsen, 1910; *schelkovnikovi bakuensis* Michaelsen, 1910; *fedschenkoi lenkoranensis* Michaelsen, 1910; *insularis* Chinaglia, 1913; *lacustris* Stephenson, 1913; *ganglbaueri bulgarica* Cernosvitov, 1937; *ganglbaueri cylindrica* Tzelepe, 1943; *ganglbaueri differentis* Tzelepe, 1943; *schelkovnikovi gracea* Omodeo, 1955: 8 [non Cernosvitov, 1938, name not replaced as synonyms exist]; *galloprovincialis* Bartoli, 1962; *hyrcanica* Kvavadze & Nikolashvili, 1980 - sometimes dated as 1979, overlooked by Easton (1983)]. Cf. ***Dendrobaena ganglbaueri*** (Rosa, 1894) with which *D. byblica* was often combined but was, nevertheless, restored by Zicsi (1991) [see Michaelsen (1900: 491; 1903: 45); Csuzdi & Zicsi (2003)] although it is not entirely certain what is the fate of sub-species listed

under *D. byblica byblica*. Sub-species are: ***Dendrobaena byblica arsianica*** Kvavadze,1985 (from Georgia) and ***D. b. herethica*** Kvavadze,1985 [**Note:** after Blakemore (2007): *D. byblica herethica* Kvavadze, 1985 [originally *D. schelkovnikovi herethica* Kvavadze, 1985: 155-157, sometimes transferred to *Omodeoia* - a junior synonym of *Dendrobaena*; the listing in Kvavadze (2000: 77) of both "*D. byblica herethica*" and "*D. heretica*" as separate taxa is a typing error and/or a mistake as the correct citation should be "*Dendrobaena byblica herethica* Kvavadze,1985" as here, with no braces needed under ICZN (1999: Art. 51.3.2) as the taxon remains in the same genus, E. Kvavadze pers. comm. to RJB, (16.ii.2007); thus "*D. heretica*" is a *lapsus calami* and *nomen nudum*]. {Note the irony of names *byblica vs. heritica*}.

Dendrobaena hortensis (Michaelsen, 1890)

Fig. 6.9.4. *Dendrobaena hortensis* from Tasmania, (a) ventral view with a nephridial bladder, (b) dorsal view of prostomium and spermathecae *in situ*. **New record.**
https://bjc792.wixsite.com/earthworm-images/dendrobaena-hortensis .

https://bjc792.wixsite.com/earthworm-images/dendrobaena-veneta .

Allolobophora subrubicunda var. *hortensis* Michaelsen, 1890: 15. [Type locality Hamburg (and Berlin). Types originally in Hamburg, 50 and Turin, 618, but present state unknown]. [Non *hortensiae* Kinberg, 1867 (= *Ap. caliginosa*) nec *hortensis* Brescher, 1901 (= *Al. chlorotica*)]. [Named after a place in Hamburg].

Allolobophora hibernica Friend, 1892: 402. [Types in Dublin: 186-189].

Eisenia veneta var. *hortensis*: Michaelsen, 1900: 477; Gates, 1943: 96.

Eisenia veneta hibernica: Michaelsen, 1900: 477.

Allolobophora veneta tepidaria Friend, 1904: 161. [Types BMNH 1928:12:31:203-9].

Allolobophora (*Eisenia*) *veneta dendroidea* Friend, 1909: 243. [Malvern. Types BMNH 1928:12:31:258-60].

Allolobophora (*Eisenia*) *veneta robusta* Friend, 1909: 246. [Types BM:1923.12.31.106-116].

Eisenia veneta robusta: Cernosvitov, 1942: 239.

Eisenia veneta tepidaris: (sic lapsus?) Cernosvitov, 1942: 239.

Eisenia birsteini Malevics, 1947: 19. [Types Moscow 57].

Dendrobaena veneta hibernica: Gerard, 1964: 38.

Dendrobaena veneta var. *hibernica* f. *dendroidea*: Gerard, 1964: 39 [possibly invalid infra-subspecific formulation].

Dendrobaena veneta var. *hortensis*: Gerard, 1964: 39.

Eisenia hortensis: Gates, 1968: 1; 1972: 103; Sims & Gerard, 1985: 84, fig. 27; Blakemore, 1999: 183.

Dendrobaena hortensis: Stöp-Bowitz, 1969: 218, fig. 36; Easton, 1983: 478 (syn. *hibernica* Friend, 1892; *veneta tepidaria* Friend, 1904; v*eneta dendroidea* Friend, 1909; *birsteini* Malevics, 1947); Csuzdi & Zicsi, 2003: 119 (syn. *hibernica* Friend, 1892; *veneta tepidaria* Friend, 1904; v*eneta dendroidea* Friend, 1909; v*eneta robusta* Friend, 1909; *birsteini* Malevics, 1947; *nicaensis* Vedovini, 1971; *pseudohortensis* Sapkarev, 1977); Blakemore, 2006; 2007.

Dendrobaena nicaensis Vedovini, 1971: 45 (sometimes quoted as 1970). [Types in Marseilles].

Dendrobaena venata hortensis (laps.): Bouché, 1972: 398.

Dendrobaena pseudohortensis Sapkarev, 1977: 37. Types?

Taxonomic Note: originally described as "*Allolobophora subrubicunda* Eisen *forma nov. hortensis* Michaelsen, 1890" although cited as *E. veneta* var. *hortensis* in Michaelsen (1900: 477); some authors mistake Michaelsen's publication date as "1889" or as "1907" when he described the unrelated *Notoscolex hortensis*. Csuzdi & Zicsi (2003: 119) inspected types and found *A. veneta robusta* to be another junior synonym.

Diagnosis: Length 15-50 mm. Variable, light rosy to reddish-violet or claret above extending ventrally over the first fifteen segments and often in the caudal (tail) region, otherwise whitish-yellow below. Body cylindrical with tail flattened. Prostomium epi- to tanylobous. First dorsal pore 5/6. Spermathecal pores dorsally in 9/10/11. Clitellum 26,27-33. Tubercula pubertatis translucent eliptical bands or pads in 29,30-31,32, integrity of 30/31 maintained (lacking the setal tumecenses of *D. veneta*). Tumescences lacking or around a and b in some of 9-13 and clitellar region. Setae widely paired.

Distribution: Europe: Germany, Russian steppes and Caucasus, Greece, Ireland, Italy, Iceland; N & S America (e.g. Oregon, California, Ohio, Virginia, Alberta, Argentina and Chile), Azores, South Africa [Port Elizabeth and Cape Town (Michaelsen, 1913)] (also sometimes reported from garden soil or composts), Darjiling and Simlain in Indian Himalayas, and now Australia: Tasmania (pers. obs.) and SA (J. Buckerfield, pers. com.) – both **new species records** for Australia/Tasmania. [Specimens possibly identified from

Japanese compost/bait worm markets in 2020 yet to be confirmed (R.J.B. pers. obs.)].

Locality: Tasmania.

Registration No.: QVM 14:3660 , north Tasmania "Ben Nevis RSD 440 Evandale. Coll. Jim Young June/July 1997" identified by RJB (see also *D. rubidus*). **New record.**

Habitat: Organic garden or farm soil (Tasmania), also from plant beds with pH 8.1, rich organic soils, "*foetid earth*", botanic gardens, greenhouses, in sewage and effluent, composts, said to "*inhabit filthy places*". Stöp-Bowitz says that nothing much seems to be known of its biology although it has been introduced extensively all over Europe in connection with the vermicomposting industry. A toilet bowl (Ohio), Gates (1968).

Behaviour: ?

Length: 15-54 mm.

Width: 1-5 mm.

Segments: 42-130. Body cylindrical, often becoming flatter or oblong posteriorly.

Colour: Variable, unpigmented or rosy reddish-violet or claret above extending ventrally over the first fifteen segments and often in the caudal (tail) region, otherwise whitish-yellow below; brown dorsal line may also occur (Gerard, cf. *D. veneta*).

Prostomium: Open epi- to tanylobous.

First dorsal pore: 5/6.

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment widely paired; (ca. 1.5:1:1.5:1:3:0.5 but setal ratios often vary intraspecifically); b and d setae often at four 'corners' of body.

Nephropores: Inconspicuous, alternate irregularly on sides above b and d lines to dorsum.

Clitellum: Saddle-shaped, 26,27,28-32,33, or levels as far forward as 24 (Gerard, 1964).

Male pores: Equatorial slits lateral of b setae, confined to 15 but distend 14/15 and 15/16.

Female pores: Minute, just lateral to b in 14.

Spermathecal pores: Paired 9/10/11 well above d lines nearer mid-dorsum.

Genital markings: Tubercula pubertatis translucent eliptical bands or pads in 29,30-31,32, integrity of 30/31 maintained. Tumescences lacking or around a and b in some of 9-14, those on 10 and 11 occasionally on white pads; also in clitellar region.

Septa: Only 13/14/15 or none thickened (7/8-9/10 thick according to Csuzdi & Zicsi).

Hearts: 7-11 (paired extra-oesophageals in 12).

Gizzard: In 17 but appearing to extend through 17-19.

Calciferous glands: Without sacs, glands widening (in 11-12?); opening into gut in 11

(lamellae in 11-13 according to Csuzdi & Zicsi).

Intestine origin (caeca, typhlosole): 20?; lamelliform typhlosole beginning in 20-25.

Nephridia: Present from 3, holoic with sausage-shaped (ellipsoidal) bladders.

Male organs: Testes/funnels 10 and 11, seminal vesicles 9-12 but either or both anterior pairs often reduced or lacking; Gates says in 9, 11 and 12.

Ovaries: Small in 13, each with one egg string that may contain 1-6 ova; ovisacs small.

Prostates: None.

Spermathecae: Paired in 9 and 10, spherical ampulla on tapering duct, adiverticulate; inseminated and iridescent in Tasmanian specimen.

Gut contents: Organic material (humus) and grits.

Remarks: Presumed to be biparental, the chromosome number is 2n=36. It it thought that this species is under-reported due to the often 'filthy places' it inhabits.

Csuzdi & Zicsi (2003: 119) report (from Csuzdi, 1988. Op. Zool. 23: 141-147) that this is a species suitable for vermicomposting and is widely used in Europe as its rate of reproduction is comparable with that of *E. fetida* averaging 1-4 juveniles per cocoon and 4.7 juveniles per week with incubation of 19.4 days and 48.8 days to maturity.

Superficially it is similar to *D. veneta*, *Murchieona muldali* and also often confused by worm-growers with *E. fetida* proper.

Dendrobaena octaedra (Savigny, 1826)

Fig. 6.9a. *Dendrobaena octaedra* Japanese specimen from Tomakomai, Hokkaido collected by RJB Oct. 2006 - showing prostomium, ventral view of anterior, side of clitellum (shaded), spermathecae and nephridial bladders *in situ*, with a section through intestine to show typhlosole, dorsal view of posterior segments.

Fig. 6.9b. *Dendrobaena octaedra* (lhs) redrawn after Sims & Easton (1999); (rhs) after Stöp-Bowitz (1969: 215, fig. 33).

Enterion octaedrum Savigny, 1826: 183. [Type locality Paris. Cotypes in Paris].

Lumbricus vetaedrus (laps.): Duges, 1838: 17.

Lumbricus flaviventris Leuckart, 1849: 159. [Types?].

?*Lumbricus puter*: Eisen, 1871: 959, fig. 15-16, 49-57 (part, see *D. rubidus*).

Dendrobaena Boeckii Eisen, 1874: 53, fig. 3. [Types?].

Dendrobaena camerani Rosa, 1882: 172. [Types?].

Allolobophora octaedra alpinula Ribaucourt, 1896: 32. [Types?].

Allolobophora liliputiana Ribaucourt, 1896: 32. [Types?].

Helodrilus (*Dendrobaena*) *octaedrus*: Michaelsen, 1900: 494 [syns. *vetaedrus* (laps.), *octoedra* (laps.), ?*flaviventris*, *puter* (part, see *D. rubidus*), *boeckii*, *camerani*, *liliputiana* + *alpinula*]; Smith, 1917: 168 (syn. *boeckii*).

Lumbricus octaedrus casterinensis Chinaglia, 1911: 4. [Types?].

Dendrobaena octaedra quadivesiculata Pop, 1938: 139. [Types BMNH 1949:3:1:631-3].

Dendrobaena octaedra: Tètry, 1937: 144; Gerard, 1964: 37; Bouché, 1972: 388; Gates, 1974: 16; Stöp-Bowitz, 1969: 214 (syns. *vetaedrus* (laps.), *puter* (part.), *Boeckii*); Reynolds, 1977: 65, fig. 18 [syn. *riparius* (part) Hoffmeister, 1845; *flaviventris* Leuckart, 1849; *puter* (part, see *D. rubidus*) Eisen, 1873; *boeckii*; *camerani*; *liliputiana* + *alpinula* Ribaucourt, 1896; *quadrivesiculata* Pop, 1948]; Easton, 1983: 479 (syn. *flaviventris* Leuckart, 1849; *boeckii* Eisen, 1874; *camerani* Rosa, 1882; *octaedra alpinula* Ribaucourt, 1896; *octaedra liliputiana* Ribaucourt, 1896; *octaedrus casterinensis* Chinaglia, 1911; *octaedra quadivesiculata* Pop, 1938); Sims & Gerard, 1985; 1999: 70, figs. 21,22; Rota & Erseus, 1997: 97; Csuzdi & Zicsi, 2003: 12, 121 [syns. *flaviventris* Leuckart, 1849: 159; *boeckii* Eisen, 1873: 53; *camerani* Rosa, 1882: 172; *octaedra alpinula* Ribaucourt, 1896: 37; *octaedra liliputiana* Ribaucourt, 1896: 32; *octaedrus casterinensis* Chinaglia, 1911: 4; *octaedra quadivesiculata* Pop, 1938 (that they list on page 12 but not on page 121); *octaedra brevisella* Bouché, 1972: 389]; Blakemore, 2004; 2005; 2006; 2007.

Taxonomic Note: Subspecies, *D. octaedra brevisella* Bouché, 1972 [non *Sc. dugesi brevisella* Bouché, 1972] was overlooked by Easton (1983) and Qiu & Bouché (1998), but cited and perhaps validated in Reynolds & Cook (1976: 81) yet included in *D. octaedra* synonymy by Csuzdi & Zicsi (2003: 121).

Diagnosis: Length 17-60 mm. Pigmented, red or violet to brown or yellowish brown with a coppery iridescence. Body cylindrical or octagonal in post-clitellar region. Prostomium epilobous. First dorsal pore 4/5-6/7. Spermathecal pores in 9/10/11/12 in d. Clitellum 27,28,29-33,34. Tubercula pubertatis as narrow band in 31,32-33,34 lateral of b. Gental tumescences sometimes around ab on some of 12, 16, 29-33.

Distribution: Siberia (Toksk to Lake Baikal), Novaya Zemlya (73°N), Ostrov Kolguyev, Europe [from Scandinavia and Russia, through Chechoslovakia, Switzerland, France and Italy to Greece (from Szederjesi & Csuzdi, 2012), Spain and Portugal (some interception - Gates, 1958)], Madeira, British Isles (dominant on Hebrides), Ireland, Iceland and

Grimsey Island, Greenland (the commonest species) and Disko Island, America [e.g. Newfoundland, Labrador, Alberta, Alaska, British Columbia, Colorado (Boulder), Washington, California to New York, Mexico City, Bogota in Columbia (see also Tulande *et al*., 2018), and Puerto Varas, and reported by Brown & Fragoso (2007) from Ecuador, Argentina, Chile & Bolivia (Unduavi, La Paz, 4,654m – Sielfeld, 2002)], Juan Fernandes Isls. Chile by Gates (1969: 3), Afghanistan?, Pakistan, Baluchistan, southern India (Palni Hills to 2100m); South Africa mostly from Drakensbergs at altitude; China (e.g. Huang, 1982: 79 misspelt "*D. ocmaedrus*"); Japan (Hokkaido from Stöp-Bowitz, 1969; Easton, 1981 and pers. obs. and Fujikawa, Shizuoka-ken by Nakamura *et al.*, 1989). Current specimen record from Tomakomai, TOEF Hokkaido University Forestry Research Station from lakeside under logs.

Locality: Not known from Australia, nor yet elsewhere in the Southern Hemisphere apart from a single report from Patagonia, Chile. Japanese specimens from Tomakomai, Hokkaido were collected by RJB (2nd Oct., 2006). UK specimen collected by RJB at Y Plas Machynlleth, 22nd VI 2013 (specimen in NHM).

Habitat: Often dominant in wet moorlands, also in mires and woodlands, peaty and acid situations (pH 3.3-7.7), occasionally limnic. From moss covered rocks in Greenland: Disko Island and Narssarssuaq (Hansen *et al.*, 2006).

Behaviour: Coils slightly on preservation as with other *Dendrobaena* spp.

Length: 17-60 mm.

Width: 2-5 mm. Body cylindrical or octagonal in post-clitellar region (on preservation).

Segments: 59,66,70-105,109.

Colour: Red or violet to brown or yellowish brown with a coppery iridescence.

Prostomium: Open epilobous.

First dorsal pore: 4/5/6/7, usually small from 4/5.

Setae (ratio of aa:ab:bc:cd:dd:U): Widely separate from 2; (1:1:1.2:1.2:8:?).

Nephropores: Single row just above b lines (or c lines posteriorly?).

Clitellum: Saddle-shaped, 27,28,29-33,34.

Male pores: Lateral slits in b and confined to 15 (sometimes reported with paler tumid lips that intrude on 14/15 and 15/16); [mistakenly listed as "*just below setal line b*" in Stöp-Bowitz (1969: 215) while his fig. 33 shows them just above b lines].

Female pores: Obscure, just lateral to b on 14.

Spermathecal pores: Three pairs in 9/10/11/12 in d lines, small [mistakenly listed as only in 9/10/11 by Sims & Gerard (1999: 79)].

Genital markings: Tubercula pubertatis narrow band 31-33,34 lateral of b. Gental tumescences sometimes around ab on some or all of 12, 16, 29-33; usually on setae a or b or both on 16; or around c setae in some of 9-12.

Septa: Thin, or perhaps 13.14, 14/15 slightly thickened.

Dorsal blood vessel: Single.

Hearts: 7-9,10; last hearts in 9 according to Rota & Erseus (1997: 97) and 9 or 10 by Csuzdi & Zicsi (2003: 122).

Gizzard: Mostly in 17 (Gates) or 17-18 (Csuzdi & Zicsi, 2003 and pers. obs.).

Calciferous glands: Moniliform in 11-12 around oesophagus (opening into gut near 10/11).

Intestine origin (caeca, typhlosole): 20; T-shaped typhlosole beginning from 20-23 according to (Gates, 1972: 89), but found to be simple lamellar around 40 [pers. obs. and Csuzdi & Zicsi (2003: fig. 6.23.2)].

Nephridia: Holoic with bladders vertically ocarina-shaped (Gates, 1972: 89; Rota & Erseus, 1997: 97), biscuit-shaped (Csuzdi & Zicsi, 2003) or sausage shaped (pers. obs.) which duct to parietes near setal b lines.

Male organs: Testes/funnels holandric in 10 & 11; seminal vesicles paired in 9, (10), 11 and 12.

Ovaries: With funnels in 13, compact.

Prostates: None.

Spermathecae: Three pairs in 9-11, sometimes contain sperm.

Gut contents: Selective feeder on organic matter.

Longitudinal muscle: Pinnate-type.

Genetics: For an mtDNA study see Knott & Haimi (2010).

Remarks: Parthenegenetic polymorphs common with up to 12 major morphs found at some sites. In Russia this species is an important converter of woodland litter; while in France its viscous trails left on bare rocks were traceable one year later by the lichens growing thereon, and so plant succession was initiated (Gates, 1972: 91).

Gates (1972: 90) cited interceptions of 50 specimens of this species by US Quarantine in 15 years from mainly European sources indicating its dispersal by transportation. He also noted that the distribution corresponds in part with the Norse and Viking settlements and voyages ten centuries ago, although it is not known how much of this range is self aquired. Dispersal in north Asia is claimed to be restricted by insufficient freeze tolerance (Berman *et al.*, 2001).

As well as tail regeneration, head regeneration was possible from 9/10 or 12/13 (Gates, 1954: 456; 1972: 91). Not stored by *Talpa* moles in Krakow (Gates, 1972: 92).

Quoting from Zicsi (1974), Csuzdi & Zicsi (2003: 122) state that litter consumption in forests is 1.07g dry wt per animal and surface cast production is 1.17g dry wt per animal, giving annual data of 32 kg litter per ha and 35 kg casts per ha.

Ploidy: Chromosome numbers variable: 120-130 regarded as hexaploid or heptaploid (7*n*, 7 x 18 = 126) in Italian Dolomites populations; 108 hexaploid (6*n*) in Greenland and Iceland; and 5*n* and 7*n* in southern and central Europe; and lesser ploidy is known and one fertilized individual with 108 mitotic chromosomes was suspected of pseudogamy (Gates, 1972: 89; Hansen *et al.*, 2006: 225); cf. biparental *Satchellius mammalis* with chromosome number 2n=34 (Sims & Gerard, 1985: 118).

Dendrobaena pygmaea (Savigny, 1826)

Fig. 6.10a. *Dendrobaena pygmaea* from Japan. Setae *a*, *b*, *c*, *d* are figured with their relative distances (ratios) on segment 12; np = nephropore; the white clitellum is shown shaded. A - cross section of body after clitellum showing intestinal typhlosole; B - nephridial bladders. [Figure from Blakemore (2004g)].

Fig. 6.10b. Distribution of *Dendrobaena pygmaea*.

Enterion pygmaeum Savigny, 1826: 183. [Type locality Paris. Types in Paris Museum]. [Non *Dendrobaena arborea pygmaea* Friend, 1923: 23 (? = *Dendrodrilus rubidus subrubicundus*)].

Allolobophora minima Rosa, 1884: 39. [From Piemont, Italy. Types unknown]. [Non *minima* Muldal, 1952 = *Murchieona muldali* (Omodeo, 1956) nom. nov., cf. *M. minuscula* (Rosa, 1906)].

Helodrilus (*Eophila*) *cognettii* Michaelsen, 1903: 140. [From Sardinia. Types in Turin: 812]. [Nom. nov. pro. *ribaucourti* Cognetti, 1901: 21 (non Bretscher, 1901 = *L. rubellus*) ; name sometimes misspelt "*cognetti*"; non *Eisenia veneta cognettii* Cernosvitov, 1935 (= *Dendrobaena alpina alpina*)].

Helodrilus (*Dendrobaena*) *pygmaeus*: Michaelsen, 1900: 495 (syns. *pigmea* Ribaucourt, 1896 (lapsus), *minima* Rosa, 1884).

Dendrobaena pygmaea: Gerard, 1964: 37; Sims, 1983: 469 (syns. *minima, cognettii*); Easton, 1983: 479 [syns. *Allolobophora minima* Rosa, 1884 (non Muldal, 1953), *cognettii* Michaelsen, 1903 (nom nov pro. *ribaucourti* Cognetti, 1901)]; Sims & Gerard, 1985; 1999: 73, fig. 23 (syn. *minima*, *cognettii*); Blakemore, 2003; 2005;

2006; 2007 (syns. as above).

Taxonomic Remarks: Bouché (1972) recognized *pygmaea* as the rare amphimictic phase and *cognettii* as the commoner parthenogenetic phase lacking dorsal pores, seminal vesicles and spermathecae, but the current author's specimens appear to partly merge this distinction and, moreover, morph/phase names are invalid under ICZN. Sims & Gerard (1985; 1999: 44) state that, on the fallacy that the original description was inadequate, some authors have attempted to replace the name *D. pygmaea* (Savigny, 1826) that was validated and legitimised by revisers such as Michaelsen (1900: 495) with the later name *D. cognettii* (Michaelsen, 1903), even though another, older name: *minima* Rosa, 1884, is available. Both these subsequent names are in synonymy as per Sims (1983), Easton (1983), Sims & Gerard (1985; 1999) and Blakemore (2007).

Diagnosis: Length 13-45 mm. Light reddish dorsum, or unpigmented. Body cylindrical tapering. Prostomium epilobous. First dorsal pore 4/5/6/7, or absent. Spermathecal pores dorsally in 9/10/11/12, frequently absent. Clitellum 32,33-37,38. Tubercula pubertatis absent or narrow ridge below b lines in 35-37. Gental tumescences absent. Setae separate.

Distribution: Britain, Germany, France, Spain (e.g. as *D. pygmaea cognettii* from Galicia or *D. cognettii* from Valencia, Canaries (Ref.), and one specimen from the northwest by Monroy *et al.*, 2003), Switzerland, Austria [as *D. cognettii* e.g. Christian & Zicsi (1999)], Italy, Sardinia, Greece, Madeira and Tenerife in the Canaries (as *D. cognettii*), Hungary [as *D. cognettii* e.g. Csuzdi & Zicsi (2003)], Romania, Bohemia in the Czech Republic [newly reported by Pizl (2003)]; also single records from Constantine, Algeria [by Rouabah & Descamps (2001)], San Francisco, California [cited by Reynolds (1995: 27), possibly from study by Gates (1975)], noted from Chile as well (Csuzdi & Zicsi, 2003: 115), and two specimens recorded (as "*Dendrobaena cognettii* (Michaelsen, 1903: 130)") from South Africa; recently discovered in Asia (coll. and det.: R.J. Blakemore, 9-10th May, 2003 from Yokohama National University campus, Japan) **as a new record for Japan/Asia**. Not yet known from Australasia nor Oceania.

Locality: Description based on Yokohama material (Blakemore, 2005).

Habitat: Well-drained soil and moist litter or mossy banks.

Behaviour: Sluggish.

Length: 13-45 mm. Body cylindrical tapering to tail.

Width: 0.5-1.2 mm.

Segments: 90-110.

Colour: Reddy anterior dorsum, or unpigmented grey (dorsum especially transparent); clitellum white.

Prostomium: Epilobous or almost prolobous.

First dorsal pore: 4/5/6/7, usually absent.

Setae (ratio of aa:ab:bc:cd:dd:U): widely separate from 2; (1.5:1:1:1.1:2:?).

Nephropores: Single row above b lines from 3 (or above c lines?); especially obvious on clitellum.

Clitellum: Saddle-shaped, 32,33-37,38.

Male pores: Lateral slits in bc on large white-pigmented pads mostly confined to 15.

Female pores: Visible just lateral to b on 14.

Spermathecal pores: Dorsally in 9/10/11/12, frequently absent.

Genital markings: Tubercula pubertatis absent (usually), or narrow ridge below b lines in 35-37.

Septa: None especially thickened.

Dorsal blood vessel: Single (visible through cuticle).

Hearts: 7-11.

Gizzard: 17 or (17-18?).

Calciferous glands : Moniliform in 11-12,13.

Intestine origin (caeca, typhlosole): Beginning with crop in 15; typhlosole simple lamellar type occurring after clitellum (pers. obs.).

Nephridia: Holoic with ocarina-shaped bladders which duct to parietes near setal b lines.

Male organs: Iridescent testis visible through body wall in 10 and 11 in Yokohama specimens suggest that it is not, or not entirely, a parthenogenetic morph; seminal vesicles in 11 and 12, frequently small or absent.

Ovaries: In 13, band-like and terminating in a single egg-string.

Prostates: None.

Spermathecae: Three or two pairs, usually absent.

Gut contents: Colloidal organic soil.

Remarks: A poorly known species with some residual dispute over the correct name due to attempted recognition of parthenogenetic morphs. The correct procedure is to adopt the earliest valid and available name, irrespective whether the particular morph referred to is the amphimictic or parthenogenetic stage. Michaelsen (1900: 495) “fixed” the name as *pygmaea*. However, as noted in generic definition above, this taxon along with *attemsi* and *octaedra* may form parthenogenetic species-complexes, possibly also

involving the biparental *Satchellius mammalis*, in which case this latter species name would take overall priority.

Dendrobaena veneta veneta (Rosa, 1886)

Fig. *Dendrobaena veneta* after Sims & Gerard (1999: fig. 28).
Fig. 6.11a. *Dendrobaena veneta* from New Zealand, IDed by RJB.
Fig. 6.11b. *Dendrobaena veneta* from Zama, Japan, Nov. 2020 IDed by RJB.
https://bjc792.wixsite.com/earthworm-images/dendrobaena-hortensis .

https://bjc792.wixsite.com/earthworm-images/dendrobaena-veneta .

Allolobophora veneta Rosa, 1886: 674. [Type locality Campo di Marte, Venice. Types?].

[Also: Rosa (1886: 1). Note sui Lombrici del Veneto (Riassunto), in: *Boll. Mus. Zool. Anat. Comp. Torino*, Vol. 1. No. 3. (1 p.)]

Dendrobaena caucasica Kulagin, 1889: 13. [Types in Moscow, 59].

Dendrobaena bogdanowi Kulagin, 1889: 14. [Types in Moscow, 58].

Eisenia veneta: Michaelsen, 1900: 477; Stephenson, 1933: 934; (non Gates, 1943: 96 – see *D. hortensis*).

Eisenia veneta zebra Michaelsen, 1903: 39. [From Transcausica. Types Hamburg 5846 and in Moscow Museum].

[*Allolobophora* (*Notogama*) *veneta succinta* Rosa, 1905: 104. Now restored as valid]*.

[*Eisenia veneta concolor* Michaelsen, 1909: 35. Types Hamburg 7408. Now restored]*.

Helodrilus venetus picta (sic?) Michaelsen, 1910: 30. [Types?].

Eisenia austriaca Michaelsen, 1936: 35. [Types Hamburg 10437].

Eisenia veneta crassa Malevics, 1947: 17. [Types not designated].

Eisenia veneta minuta Malevics, 1947: 18. [Types not designated].

Dendrobaena svetlovia Grieb, 1948. [Types?].

Dendrobaena veneta typica: Gerard, 1964: 38.

Dendrobaena veneta zebra: Gerard, 1964: 39.

Dendrobaena (*Dendrobaena*) *veneta veneta*: Bouché, 1972: 398.

Eisenia veneta: Sims & Gerard, 1985: 88, fig. 28 (syn. *zebra*), 1999 (ditto); Blakemore, 1999: 183.

Dendrobaena veneta: Perel, 1979: 231 (part.); Kvavadze, 1985: 122; Szederjesi *et al.* 2019: 306.

Dendrobaena veneta veneta: Easton, 1983: 479 (syn. *bodganowi* Kulagin, 1889; *causasica* Kulagin, 1889; *veneta zebra* Michaelsen, 1902; *veneta succinta* Rosa, 1905; *veneta robusta* Friend, 1909 [found to be *D. hortensis* by Csuzdi & Zicsi, 2003: 119); *venetus concolor* Michaelsen, 1910; *veneta picta* Michaselsen, 1910; *veneta tumida* Friend, 1927: 281 (nom. nud.); *austriaca* Michaelsen, 1936; *veneta balcanica* Cernosvitov, 1937 [originally *Eisenia veneta balcanica* Cernosvitov, 1937; removed from synonymy of *D. veneta veneta* and elevated to specific rank by Zicsi & Csuzdi (1986: 115), non. *Eisenia rosea balcanica* Cernosvitov, 1942]; *veneta minuta* Malevics, 1947; *veneta crasa* Malevics, 1947; *svetlovia* Grieb, 1948); Csuzdi and Zicsi, 2003: 127 (syn. *causasica* Kulagin, 1889: 13; *bodganowi* Kulagin, 1889: 14; *veneta zebra* Michaelsen, 1902; *veneta succinta* Rosa, 1905; *venetus concolor* Michaelsen, 1909; *veneta picta* Michaselsen, 1910; *austriaca* Michaelsen, 1936; *veneta crasa* Malevics, 1947: 17; *veneta minuta* Malevics, 1947: 18; *svetlovia* Grieb, 1948); Csuzdi, 2007 (website); Blakemore, 2005; 2006; 2007, 2008, 2016.

Dendrobaena venata venata (laps.): Qiu & Bouché, 1998: 194.

***Taxonomic Note:** Easton (1983: 479) lists three sub-species of *Dendrobaena veneta veneta*, these are:-

D. veneta kervillei (Michaelsen, 1910; 1926) [syn. *Eisenia veneta kervillei* Michaelsen, 1910; 1926: 352 non *Dendrobaena semitica kervillei* Michaelsen, 1926: 353 (= *D. semitica michaelseni* Easton, 1983); species described twice by Michaelsen; types lost]; ***D. veneta meleica*** (Tzelepe, 1943: 1) [types unknown]; and ***D. veneta ochridana*** Sapkarev, 1977 (types?).

There is some residual confusion about the status and nomenclature of some of these sub-specific names (e.g. see Csuzdi, 2002 where he elevates *D. kervillei* to specific status as its cliltellum occupies 25-34 and TP are on 30-32).

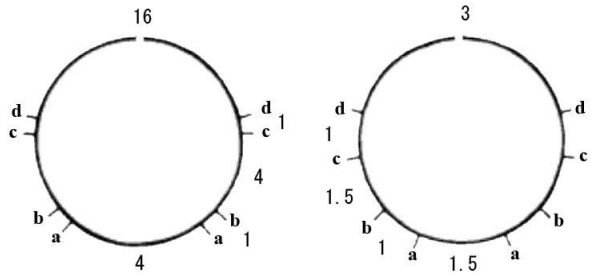
Kvavadze (1985) noting Caucasian forms bearing uniform pinkish coloration and setal differences, resurrected *D. concolor* (Michaelsen, 1909) from synonymy.

Recently, Szederjesi *et al*. (2019) restored *Dendrobaena succinta* (Rosa, 1905), putting *D. concolor* (Michaelsen, 1909) in its synonymy and they noted it as a free-living form of *D. veneta* "*mostly distributed in the East Mediterranean, .. bearing pinkish pigmentation and usually found in the upper soil layer in natural habitats*." They also maintined *D. hortensis* as a valid separate taxon supported with mtDNA (see also https://www.researchgate.net/publication/326050162_Earthworms_and_Vermicompostin

g/fulltext/5b3587080f7e9b0df5d834a6/Earthworms-and-Vermicomposting.pdf).

Dendrobaena succinta (Rosa, 1905) Szederjesi *et al*. restored and differentiated with: "*The most notable morphological difference between* D. veneta *and* D. succinta *is the pigmentation:* D. veneta *always bears stripy pigmentation, while* D. succinta *has a uniform purple-red coloration in different shades. They also differ in the thickened dissepiments, the setal arrangement and the expansion of the calciferous glands.*" Its distribution is from Turkey and the Caucasus, Thodes, Crete, Cyprus and Jordan.

A notable difference between *D. veneta* and *E. fetida* , apart from the larger size and wider setal pairing, it its pronounced pale or pink clitellum, whereas *E. fetida* has a reddy clitellum. Setae in *D. veneta* can be seen dorsally, unlike in *E. fetida* where they are more ventral possibly allowing it to climb more easily (figure below has setal ratios):



Eisenia fetida ***Dendrobaena veneta***

Setal ratios close or wide (not to scale)

Diagnosis: Musty smell (similar but not as strong as *E. fetida*) and does not readily exude yellow coelomic fluid when prodded (as *E. fetida* does). Length 20-155 mm (usually 50-100). Banded, with a conspicuous dense claret mid-dorsal stripe and intrasegmental bands mainly incomplete ventrally except possibly for a few anterior segments, intersegments and ventrum pale or yellowish. Caudal segments with accumulation of yellow coelomocytes (as seen in *E. fetida* too). Body cylindrical but clitellum flared with tail often flattened. Prostomium proepi- to tanylobous. First dorsal pore 5/6. Spermathecal pores dorsally in 9/10/11. Clitellum 26,27-32,33,34 (mostly 26,27-33). Tubercula pubertatis in b lines extends 29,30-31,32 or distinctly papillate on 30 and 31. Tumescences around a and b in clitellar region (28-32) or at least on 30 and 31 (cf. *D. hortensis*). Setae widely paired.

Distribution: Natural range from the Caucasus westwards through Russia (Stop-Bowitz), Poland (Ref.) and also the Levant to Crete (Michaelsen, 1902), Italy (type locality) and on into Spain and northern Europe except for the frozen North, but it now occurs there in greenhouses (e.g. in Finland Ref.). In the UK it was first recorded before 1923 (e.g. from Kew - Ref.). and worm breeders often concentrate on *Dendrobaena*

veneta since it can be used by both the fishing and composting market. Introduced to California (reported as *Eisenia zebra*) and other states in US, Brazil (Knäpper & Porto, 1979), Chile (Sielfeld, 2002), Argentina (on InBiAr website http://www.uns.edu.ar/inbiar/ but possibly a mistake for *D. hortensis*), South Africa (e.g. Viljoen *et al*. 1991; Muyima *et al*. 1994) where it is reported from garden soils and compost heaps and also from China (Huang, 1982: 76). Also from South Australia (J. Buckerfield, pers. com.) – a new record for Australia; from New Zealand (pers. obs.) – **a new record for that country**. Recent reports are from Iran (Ref., Ref.). In 2020 specimens were obtained from bait and worm growers and online catalogue images from as early as at least 2018 and my own records from 2002 now confirm it has been introduced to Japan (pers. obs.) **as a new record**.

A Belgian worm grower claims "*We ship all over Europe and started shipping to the US in 1995. Export of worms all over the world*" while US Gov. Aphis website says: "*Eisenia (=Dendrobaena) veneta* and *D. hortensis* are currently the only earthworm species that are permitted for importation into the U.S. from countries other than Canada for release into the environment. However, import permits for environmental release are only issued for receipt from certain European countries that are free from foot-and-mouth disease." Japanese specimens possibly came from US or less likely from EU.

Locality: New Zealand specimen sent to author in 1992 Landcare Crops NZ from samples "*supplied by an Auckland worm farmer with Dr Fraser and colleague, Jacqueline Piercy, making the initial identifications, later confirmed by an Australian earthworm taxonomist* [i.e., RJB!]". Material also identified from images on US worm farm websites and recently confimed (e.g. Blakemore 2020) as cultured in Japan.

Incidentally, a UK report found only 1 of 25 specimens from 8 suppliers of "*Eisenia fetida*" were correct (its confusion with *E. andrei* notwithstanding), most were *D. veneta.*

Human uses: As well as vermicompost and bait markets, a recent publication (Szederjesi *et a*l. 2019) lists its application for "*several cell-biological (Siekierska 2003; Adamowicz 2005), immunological (Molnár et al. 2015; Swiderska et al. 2017), soil biological and environmental studies (Marinussen et al. 1997; Natal-da-Luz et al. 2011)*." A 2019 study (Ref.) found anti-tumor effect from *D. veneta* coelomic fluid on human lung cancer cells as "*an interesting and promising preparation for further biological, chemical, and biomedical research*." [Cf. medical uses of *Eudrilus* (Ref.)].

Habitat: Under decaying leaves, commonly in organic rich soils, compost, manure, sewage beds, rhubarb crowns.

Behaviour: Fairly docile and easy to handle. Body often flattens. Said to readily escape worm beds. The smell is less pungent than *E. fetida* and it does not readily expel yellow fluid from tail segments like *E. fetida* does. Larger in size, the reproductive rate is about one tenth that of *E. fetida*.

Length: 20-155 mm.

Width: 4-8 mm.

Segments: (54)86-255. Body cylindrical, often becoming flatter posteriorly.

Colour: Banded, with a conspicuous dense claret mid-dorsal stripe and intrasegmental bands mainly incomplete ventrally except possibly for a few anterior segments (2-7,8), intersegments and ventrum yellowish and caudal coelomocyctes visible.

Prostomium: Proepi- to tanylobous (e.g. Stephenson, 1933, text-figs. 26-27) or just epilobous (Csuzdi).

First dorsal pore: 5/6.

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment widely paired; (ca. 1.5:1:1.5:1:3:0.5).

Nephropores: Inconspicuous, alternate irregularly on sides above b and d lines.

Clitellum: Saddle-shaped, 26,27,28-32,33 [or levels as far forward as 24 (Gerard, 1964) and as far back as 34 (Csuzdi, 2007)].

Male pores: Small equatorial slits lateral of b setae, prominent but confined to 15.

Female pores: Minute, just lateral to b in 14.

Spermathecal pores: Paired 9/10/11 well above d lines nearer mid-dorsum.

Genital markings: Tubercula pubertatis in b lines extends 29,30-31,32 and is pronouncedly papillate on 30 and 31 or in 29-30 and 31-32 (in current specimens); with tumescences around a and b in clitellar region or at least those on 30 and 31. Csuzdi (2007) describes tumescences around ab on 10, 11, 28-32 and tubercles on 30-31.

Septa: 5/6-12/13 slightly thickened, 13/14/15 strongly muscular (or just 10/11/12/13 according to Csuzdi & Zicsi, 2003).

Hearts: 7-11 (with a pair of extraoesophageal vessels in 12).

Gizzard(s): In 17-18 (crop in 15-16).

Calciferous glands: Without sacs, gland widening (in 10-11 or 11-12?); opening into gut in 11.

Intestine origin (caeca, typhlosole): 20?; simple typhlosole beginning in 20-25.

Nephridia: Holoic with (sausage-shaped?) bladders.

Male organs: Testes/funnels 10 and 11, seminal vesicles 9-12 (or 9,11,12 or just 11, 12).

Ovaries: Small in 13.

Prostates: None.

Spermathecae: Paired in 9 and 10, spherical ampulla on tapering duct, adiverticulate.

Gut contents: Organic material.

Remarks: Biparental, the chromosome number is 2n=36m, spermatophores may be present in region of 27-29. Also used in vermicomposting according to Csuzdi & Zicsi (2003: 129) and pers. obs., but its reproductive rate is apparently not as great as *E. fetida* nor *D. hortensis*.

Note: DNA: From Genbank KT823850:

1 ataaagatat tggaaccctt tacttcattt taggtatttg agccggaata gtgggtgctg

61 gaataagact actcattcga attgaattaa gacaacctgg tgccttttta ggcagagatc

121 aattatacaa caccattgtt acagcacacg cctttgttat aattttcttc ttggtgatac

181 cagtatttat tgggggattc ggaaactgac tcctcccccc aatactaggg gccccagata

241 tagcatttcc ccgactaaac aacataaggt tttgattact accaccctca ctaattctat

301 tagtttcttc tgctgccgta gaaaaaggtg ctggcacagg atgaaccgtt tatcctccac

361 tagcaagaaa tttagcacat gctggcccct cagttgattt agccattttc tctctacatt

421 tagcaggggc ctcatcaatc ttaggagcca ttaacttcat tactactgta gttaatatac

481 gatgaactgg aatacgatta gaacgtattc ctctgttcgt ttgagccgta attattacag

541 ttgttcttct tcttctctcg cttccagttc ttgccggagc tattactata ctcctaacag

601 atcgaaacct aaatacctca ttctttgatc

Genus ***Dendrodrilus*** Omodeo, 1956 [= *Bimastos*?]

Dendrobaena (*Dendrodrilus*) Omodeo, 1956: 175.

[Csuzdi et al. (2017) consider it a synonym of North American *Bimastos*].

Type-species: *Enterion rubidum* Savigny, 1826 by original designation.

Diagnosis: Calciferous sacs in 10 opening posteriorly into the oesophagus ventrally just in front of 10/11. Calciferous lamellae continued anteriorly along the lateral walls of the sacs. Nephridial vesicles form J- or U-shaped loop. Nephropores alternate irregularly on each side of the body above b and d lines. Prostomium epilobous. Pigment red. Dorsal pores from the region of 5/6. Setae relatively widely paired. Musculature pinnate with slight intermediate characters (Csuzdi & Zicsi, 2003: 133).

Distribution: Origin in Palaearctic/Holarctic? Monotypic, although four component subspecies (or probably, parthenogenetic morphs) are still distinguished, having a wider global range by introduction than almost any non-cultured earthworm – known from all bioregions, but excluded from tropical lowlands.

Remarks: *Dendrodrilus* was up-graded from a sub-genus of *Dendrobaena* because of the supposed conservative somatic (i.e., non reproductive) anatomy of the type-species. In later revisions, two or three sub-species or morphs are included along with the type-species; these four entities are differentiated in **Remarks** following the description of the *D. rubidus* species-complex below.

Basic chromosome number is reported as n=17 and ploidy is common.

Csuzdi *et al*. (2017) consider the genus a synonym of North American *Bimastos*. They also include *tenuis* and, *subrubicundus* as junior synonyms of the type *D. rubidus* (but they make no mention of *constrictus* nor *norvegicus*). Such a conclusion does not differ from earlier species summary by Blakemore (2008) and as presented below. The question of absorption in *Bimastos* is not unreasonable, but purely for historical convenience is here maintained in untenable genus *Dendrodrilus*.

Dendrodrilus rubidus species-complex

Separated into component taxa following composite description below.

Dendrodrilus rubidus (Savigny, 1826)

Fig. 6.12a. *Dendrodrilus rubidus rubidus* from Okutama, Japan (annotated photograph of lateral view of specimen collected by R.J.B, 2002).

Fig. 6.12b. *Dendrodrilus rubidus tenuis* from Biggles Track, Brothers Point to Green Gorge, Macquarie Island (collected 20.x.1997 by R.J.B.); (sketch shows nephridial bladder opening in b lines on 14; gut, from calciferous glands to gizzard; and setal ratio on 20. Clitellum shaded; d.p. - dorsal pore; TP - Tubercula Pubertatis. NOTE: spermathecae absent, seminal vesicles in 11-12 only and in life the tip of tail yellow).

Fig. 6.12.1. *Dendrodrilus rubidus* ?*subrubicundus* sketch from AM W24583 specimen from Bobbin Head, NSW. NOTE: TP 28-30, seminal vesicles 11-12 only and no spermathecae so probably *tenuis* morph.

Fig. 6.12.2a. *Dendrodrilus rubidus tenuis* sketch from QVM T3661 from Evandale, Tasmania.

Fig. 6.12.2b. *Dendrodrilus rubidus tenuis* sketch of one of five spex from AM:W197224 from "*Michilago (Southern Railway) within 2 miles of Murumbigee River. Coll T.G. Sloane 16.4(18)89*"; misidentified by E. Easton 1.3.(1983) as "*Eisenia hibernica* (Friend, 1892)", pers. obs. R.J.B. 31.v.1998.

Fig. 6.12.2c. *Dendrodrilus rubidus* Tomakomai Hokkaido specimen with seminal vesicles in 9, 11-12 but lacking spermathecae (*rubidus* or perhaps *tenuis* morph),

collector RJB 2.x.2006 from lakeside.

Fig. 6.12.2d. *Dendrodrilus rubidus tenuis* Tomakomai Hokkaido specimens, with seminal vesicles in 11-12 only and lacking spermathecae, YNU collection [figure shows neprhidium (from anterior), prostomoum (and dorsal pores), ventral body, and side views of clitellum region, typhlosole section, expanded nephridium (from after clitellum) and the posterior 'tail' region].

Included taxa (and synonyms):

Enterion rubidum Savigny, 1826: 182. [Type locality Paris. Types in Paris Museum].

?*Lumbricus xanthurus* Templeton, 1836: 235; Johnston, 1865: 62 (cf. *Eisenia fetida*). [From Ireland. Types missing].

?*Lumbricus olidus* (part?): Hoffmeister, 1945: 32.

?*Lumbricus puter* Hoffmeister, 1845: 33. [Types missing]; Johnston, 1865: 62 (as "*L. putor*").

?*Lumbricus valdiviensis* Blanchard, 1849: 43. [From Chile. Types in Paris]. [Sometimes misspelt "valdivensis"].

?*Lumbricus pieter* D'Udekem, 1865: 41. [Types?].

?*Hypogeon havaicus* Kinberg, 1867: 101. [From Hawaii. Types Stockholm: 1941]. [Likely synonym of *subrubicundus* ; sometimes spelt "*havaicum*"].

?*Lumbricus victoris* (et *dictoris* laps.) Perrier, 1872: 41 (*Dictoris*) laps., 48. [From Damiette, Egypt (as stated by Perrier on page 103). Types?]. [Its synonymy may be questioned as it was described by Michaelsen (1900: 495) with first dorsal pore in 7/8 or 8/9; clitellum 26-33 or 27-34; spermathecae (three pairs?) lateral in 9,10,11; three pairs of seminal vesicles; and of medium size]. *Species inquirendum.*

?*Allolobophora arborea* (part?) Eisen, 1873: 49. [Types Stockholm 34]; Eisen, 1874: 9, fig. 6.

?*Allolobophora tenuis* Eisen, 1874: 44. [Types?].

Allolobophora norvegica Eisen, 1874: 48. [Types Stockholm 35].

Allolobophora fraissei Orley, 1881: 285. [Types?].

Allolobophora subrubicunda Eisen, 1874: 51. [Types Turin 547].

Allolobophora constricta Rosa, 1884: 38. [Types?].

Allolobophora putra (part.): Vejdovsky, 1888: 41*.

Allolobophora subrubicunda Eisen var. *pallescens* Friend, 1893: 189, tab. 1. [Perhaps from West Ham, or Epping forest. Types?]. [Non Eisen, 1871. Said to differ from type by larger size; appears to have been subsequently overlooked]. **Syn.**

nov.

?*Allolobophora putris arborea* Michaelsen, 1890: : 49. [Type in Turin: 541 according to Reynolds & Cook (1976), but this is possibly a mistaken taxon or an invalid homonym]. [?Non *arborea* Eisen, 1873].

[?"*Allolobophora putris* Vejdovski", date? - citation by Ribaucourt, 1896: 18]*.

Allolobophora putris subrubicunda var. *helvetica* Ribaucourt, 1896: 18. [From Morgins (1,300 m), Heustricht (800 m), Berne (540 m) , StImier (819 m), Switzerland. Types?].

Allolobophora darwini Ribaucourt, 1896: 82. [Niesen Alps 2,300m. Types?].

Helodrilus (*Dendrobaena*) *rubidus* : Michaelsen, 1900: 490 [syn. ?*xanthurus*, ?*puter* (part, see *D. octaedra*), ?*pieter* (part), ?*putra* (part), ?*havaicus*, ?*arborea*, ?*tenuis* (part) - balance syn. *Allolobophora constricta* Rosa, 1884 by Michaelsen (1900: 503); - Michaelsen (1900: 490) also listed *H.* (*D.*) *rubidus subrubicunda* (Eisen) separately with these synonyms: ?*xanthurus*, ?*puter* (part, see *D. octaedra*), ?*pieter* (part), ?*putra* (part), ?*valdiviensis*, *fraissei*, *rubicunda* (laps.): Beddard, 1891: 273; *nordenskiöldii* (laps.): Michaelsen, 1891: 3, *helvetica* + *darwini* Ribaucourt, 1896: 18, 82].

[?"*Allolobophora putris* Hoffm.", date as for *puter* 1845? - citation by Beddard, 1900: 414 (syn. *Hypogaeon havaicum*)]*.

[?"*Allolobophora putris* Rosa", date? – citation by Wessely (1905: 10) (syn. *Lumbricus puter* Hoffmeister possibly also spelt as "*L. putor* Hoffmeister" (= *L. minor*?) by Johnston (1865: 62); *Allolobophora subrubicunda* Eisen + *A. arborea* Eisen)]*.

[?"*Allobophora putris* Vedj.", date? citation by Beddard, 1896: fig. 200]*.

Dendrobaena subrubicunda v. *papillosa* (part.) Pop, 1943: 21.

Bimastos tenuis : Gates, 1943: 97.

Dendrobaena magnesa Tzelepe, 1943: 1 (38?). [Types?].

Dendrobaena rubida: Lee, 1959: 30; Stöp-Bowitz, 1969: 220, fig. 38; Gates, 1972: 92.

Dendrobaena (*Dendrodrilus) rubidus*: Omodeo, 1956: 175.

Dendrobaena (*Dendrodrilus) rubida rubida*: Bouché, 1972: 410 (syn. *norvegica* Eisen, 1874).

Dendrodrilus rubidus: Easton, 1981: (syn. *tenuis*); Sims & Gerard, 1985; 1999: 76, fig. 24 (syn. *tenuis*, *norvegica*, *subrubicunda*).

Dendrodrilus rubidus rubidus: Easton, 1983: 479 [syns. *xanthurus* Templeton, 1836; *puter* Hoffmeister, 1845 (cf. *D. octaedra*); *valdiviensis* Blanchard, 1849; *pieter*

Udekem, 1865; *havaicus* Kinberg, 1867; *victoris* Perrier, 1872; *arborea* Eisen, 1874; *fraissei* Örley, 1881; *constricta* Rosa, 1884; *darwini* Ribaucourt, 1896; *putris subrubicunda* var. *helvetica* Ribaucourt, 1896; *putris subrubicunda papillosa* Pop, 1938; *magnesa* Tzelepe, 1943; Easton (1983: 479) also had *D. rubidus subrubicundus* with these synonyms: *putris dieppi* Ribaucourt, 1901; ?*arborea pygmaea* Friend, 1923, *rivulicola* Chandebois, 1958; and Easton (1983: 480) had *D. rubidus tenuis* subspecies without synonyms; Csuzdi & Zicsi, 2003: 132 (syns. *xanthurus, puter, pieter, havaicus, arborea, tenuis, constricta, darwini, putris subrubicunda helvetica, magnesa*; - these authors also have synonyms for *rubidus subrubicundus* Eisen, 1874 of ?*valdiviensis* Blanchard, 1849: 43 – that, if so, would possibly take priority?; *fraissei*, *putris dieppi*, *subrubicunda papillosa*, and *rivulicola*); Blakemore, 2004; 2006; 2007 (syns. as above)].

*Taxon "***Allolobophora putris*** Hoffm." is listed by Beddard (1900) where he says "This apparently is the same as Kinberg's '*Hypogaeon havaicum*'"; I can find no primary citation nor authority; other than Michaelsen (1900: 490, 491, 503) has his taxon "*A. putris* forma *arborea* (part?), Michaelsen,1890: 49" under the taxa: *H.* (*D.*) *rubidus*, *H.* (*D.*) *rubidus* var. *subrubicunda* and *H.* (*B.*) *constricus*, respectively. Probably the name "*putris*" is derived from "*puter* Hoffmeister, 1845" or its derivative "*putra* Vejdovsky, 1888", which possibly also declines in Latin as "*putor*", or is misspelt so. "*Puter*", in Latin means "rotten"; its Vocative declension is: ***puter*** m., ***putris*** f. and ***putra*** n.

Taxonomic Remarks: Csuzdi et al. (2017) include *tenuis* and, *subrubicundus* as junior synonyms of the type *D. rubidus*. The earlier revision by Csuzdi & Zicsi (2003: 133) regarded *tenuis* Eisen, 1874: 44 as a synonym of *Dendrodrilus rubidus* (Savigny, 1826: 182), despite its different state of polyploidy, and *subrubicundus* Eisen, 1874: 51 as a sub-species [NOTE: page priority!]. From inspection of types, Csuzdi & Zicsi (2003: 137) also found *A. fraissei* Orley, 1881 and *D. subrubicundus v. papillosa* Pop, 1938 to be identical with *D. r. subrubicundus*. Although Sims & Gerard (1985; 1999) combined them, Easton (1983: 479-480) had listed separately the three subspecies of *D. rubidus rubidus*, viz.: *D. rubidus norvegicus* (Eisen, 1874), *D. rubidus subrubicundus* (Eisen, 1874), and *D. rubidus tenuis* (Eisen, 1874). These are differentiated under **Remarks** below. Qiu & Bouché (1998: 195) elevated them all to species status without detail nor inspection of types, thus somewhat speculative as far as can be determined

logically.

The *Allolobophora constricta* Rosa, 1884 morph lacking genital markings and spermathecae and included by some authors as a part of *Allolobophora parva* (= *Bimastos parvus*), is now (Easton, 1983) included in *D. r. rubidus*, although Omodeo & Rota (2004: 250) suggest reservation of the name *D. rubidus constrictus* "*to the forms devoid of spermathecae*" which may correspond to the "*parthenogenetic morph*" of *D. r. rubidus* suggested by Csuzdi & Zicsi (2003: 131), and thus equivalent to *D. tenuis*.

Diagnosis: Length 20-100 mm. Variable, dark red dorsum, pale ventrum or pale with yellow tip to tail. Body usually cylindrical. Prostomium epilobous. First dorsal pore 5/6. Spermathecal pores in 9/10/11, frequently absent. Clitellum 25,26,27-31,32. Tubercula pubertatis ventral on edge of clitellum broad in 28-30,31 or slender in 29-30, sometimes absent. Tumescences around ab on 16, or some of 9,17, 22-25,30. Setae widely paired.

Distribution: Cosmopolitan species-complex, probably indigenous to Holarctic: fossil cocoons were found in postglacial deposits in Ontario by Schwert (1979) and Gates (1943: 97) had described this species as still occurring on Manitoulin Island, Ontario. A theory of survival of preglacial populations on barren nunataks in Nearctic is not necessary as recolonization by human reintroduction is common (Gates, 1967, 1972: 94) dating from the Viking era. Confirmed from Hokkaido and Honshu, Japan (Stöp-Bowitz, 1969: 229 also had a specimen from there), Korea, China (Manchuria), Kamchatka and western Siberia throughout Europe, (e.g. widespread in Britain, from southern England to Faeroes and Hebrides where the three morphs occur under dung-pats with *tenuis* also in dunes and machair – the crofters' dune farming system; *constrica* was found in rotten wood in Queen's Cottage Grounds (Kew?) – Beddard, 1895: 711); Iceland and Grimsey Island e.g. as *Dendrobaena subrubicunda* by Kunst (1959); Greenland and Disko Island; Newfoundland other Canadian provinces to Alaska; USA (many states); Mexico, Central and South America including Colombia [from Michaelsen (1913) in Feijoo *et al*. (2004) where it is erroneously recorded as "*Bimastos constrictus*", the *tenuis* morph also present], Bolivia, Argentina, Brazil, Venezuela, Uruguay, Equador, Peru, Chile and Tierra del Fuego (Brown & Fragoso, 2007) and Falkland Islands (recorded as "*Malvinas Isl*." by Mischis in Brown & Fragoso, 2007: 249), Africa north and South, Azores, Madagascar, northern India, Bhutan and Himalayas, Hawaii and other oceanic islands including sub-Antarctic, New Zealand and Australia. Smith's (1876: 159-160) early report of *Dendrodrilus subrubicundus* (Eisen, 1874) from Ashburton and Springston-Leeston Rd. near Lincoln was listed by Lee (1959) as *Dendrobaena subrubicunda* –

here it is restored with subspecific status under *Dendrodrilus rubidus rubidus* (Savigny, 1826). In Australia, found in all States and Territories (except NT); early references are Michaelsen (1907a: 24) who reports *subribicundus* and *constrictus* (= *tenuis*) from Blue Mtns., and Stephenson (1933: 938) who records *rubidus* from Toowoomba, Qld. Gates (1972: 93) details distribution and habitat records but says that *D. rubidus* almost certainly is lacking from the Malay Peninsula.

The global range excludes only tropical lowlands; the *subrubicundus* and *tenuis* morphs are the most widespread, followed by *rubidus* and then *norvegicus*.

Locality: Current studies by RJB from NSW, SA, and Tasmania including Macquarie Island; also from Japan: Yamanashi, Okutama, and Biwako all in Honshu, and Tokakomai, Hokkaido; also from Golden Springs near Taupo, New Zealand (collected 11th September, 2011 by RJB, dissected and held in Auckland Museum: AMNZ 5259) .

Registration No.: AM W.197224 labelled "*Michilago [Michelago] (Southern Railway) within 2 mls of Murumbigee [Murrumbidgee] River. Coll. T.G. Sloane 16.3.[18]89*." "*Eisenia hibernica* (Friend, 1892). Id. by E. Easton 1.3.83." This early collection locality is just outside what is now the ACT; there are five mature specimens that are in brittle condition but appear to all be *D. rubidus rubidus/tenuis*. AM W.24583 "*Worm from soil with ...[?] 22.10.69 Bobbin Head [NSW] A.B. Rose*". Specimen 10 mm long identified by current author as *D. rubidus tenuis*. QVM 14:3661 "*Ben Nevis RSD 440 Evandale Coll. Jim Young June/July 1997*" identified by current author as *D. rubidus tenuis*; "*Biggles track, Brothers Pt to Green Gorge. 20.x.1997 R.J.B. Sample 2*" from Macquarie Island specimen identified as *D. rubidus tenuis* because spermathecae and seminal vesicles in 9 were lacking; 14:3599 "*Macquarie Island, Site 13 Overland Track to Bauer Bay 30.xi.96 C. Crossley and B. Kemp*", identified by RJB. as *D. r. tenuis*. BM:1976.13.669.720 "*Loc: No 6 Marion Island, Indian Ocean. Coll: Van Zinderen. Det: E.G. Easton*" many specimens identified by Easton as *D. r. rubidus*, reinspected by RJB although spermathecae were not found. Specimens collected 2002-2009 from Yamanashi-ken and Okutama and from Hokkaido and Lake Biwa-ko, Japan plus New Zealand specimen also identified by current author as *D. rubidus* (*tenuis*?).

Habitats: Woodlands, found under stones, moss or moist litter; present in marshes, composts, sewage filtration beds, caves; sometimes limnic or arboreal, often on cabbages or lettuces (a means of dispersal); paddock (New Zealand). Found in the Urals in saline soils and in dung heaps as well as in rotten trees. Recovered alive from natural ice, and in laboratory survived almost total immersion for about one year; cocoons survive liquid

nitrogen (-196°C – Ref.). Specimens (of *D. norvegica*) were found in milk in Norway (Stöp-Bowitz, 1969: 234). Tolerant of acid soils. (Gates, 1972: 94-95). Its wide environmental tolerances have earned this species-complex the accolade of "*a latitude of adaptation unparalleled by any other invertebrate*" (Gates, 1972: 94).

Behaviour: Specimens can fling themselves around by several rapid side-to-side motions, or be passive once captured; activity and breeding are supposedly year round

Length: 10-100 mm.

Width: 2-5 mm. Body cylindrical, sometimes slightly compressed around flared clitellum.

Segments: 50-120.

Colour: Variable, dark red dorsum, pale ventrum; or pigmented light or absent but with yellow tip to tail caused by accumulation of coelomocytes in last 3-8 segments.

Prostomium: Open epilobous.

First dorsal pore: 5/6, (or 3/4-6/7) inconspicuous or open.

Setae (ratio of aa:ab:bc:cd:dd:U): Widely paired from 2; (ca. 2:1:2:1:12<0.5?).

Nephropores: Alternate irregularly on each side of the body above b and d lines.

Clitellum: Saddle-shaped, 25,26,27-31,32; often 25-32.

Male pores: Lateral slits in bc on tumid lips mostly confined to 15 or large and extending into 14/15 and 15/16.

Female pores: Small slits just lateral to b on 14.

Spermathecal pores: 9/10/11 slightly above c lines, often absent.

Genital markings: Tubercula pubertatis ventral on edge of clitellum broad in 27,28,29-30,31 or slender in 29-30, sometimes absent. Gental tumescences surround ab on 16 in some morphs, also often on 8-11, 17, 22-25, 30.

Septa: 5/6-9/10,11/12 slightly thickened.

Dorsal blood vessel: Extra-oesophageal trunks pass to dorsal trunk in 12.

Hearts: 7-11.

Gizzard: 17.

Calciferous glands: Sacs in 10 opening posteriorly into the oesophagus ventrally just in front of 10/11 then extending back two or three segments as internal striations; appearing annular in 10 and 11.

Intestine origin (caeca, typhlosole): 15; typhlosole from 20.

Nephridia: Holoic, vesicles form J- or U-shaped loops (in Bobbin Head specimen they have thin "hairpin" shape; New Zeland specimen they are thickly V-shaped;

Csuzdi et al. (2017) only allow "*U-shaped throughout*").

Male organs: Testes/funnels holandric; seminal vesicles in 9, 11 and 12 – anterior pair small or sometimes absent.

Ovaries: In 13 as compact bunch.

Prostates: None.

Spermathecae: Two pairs in 9 and 10 the ampulla oval, or degraded, or often absent.

Gut contents: Dark soil and organic debris.

Remarks: *Dendrodrilus rubidus* is surely a polymorphic species-complex with implied parthenogenesis – both thecal and athecal morphs reared in isolation produced viable cocoons according to Gates (1972: 93). Four major morphs are currently recognized, sometimes given subspecific (or specific?) status, characterized (Michaelsen, 1900; Gerard, 1964; Stöp-Bowitz, 1969; Easton, 1983; Csuzdi & Zicsi, 2003: 133) thus:

rubidus (Savigny, 1826: 182). Colour red, darker dorsally. Body circular. Tubercula thin resticted to 29 and 30. Setal ratio, aa=2ab. Tumescences around ab on 16. **Spermathecal pores present** (except *constricta/tenuis* morphs?). Seminal vesicles 9, 11, and 12. Chromosome numbers in UK are 2n=34; in Greenland and North Iceland 6n=102; in South and Western Iceland in 2n=34. Biparental.

tenuis (Eisen, 1874: 44). Colour brown-red dorsally with blue tint, ventrum and intersegments pale and tail tip yellow. TP often indistinct or absent, when present on 28,29-30,31. Setal ratio, aa=3ab. **Spermathecae usually, but not always, absent or incomplete**. Seminal vesicles in 11-12. Chromosome numbers are 48 [i.e., (3 X 17)-3)] in English parthenogens; cf. in the Eastern Alps 6n=102. Reproduction pseudogamic?

norvegicus (Eisen, 1874: 48) [non Bretscher, 1899 (= *Ap. handlirschi*)]. Clitellum 26-32. Tubercula ½28-31 (or on 28, 29, 30, 31). Tumescences around ab on 16. Setal ratio, aa=2ab. **Spermathecae present**. Seminal vesicles in 11-12. [From Tromso, also northern Sweden and Greenland; Kerguelen Isls (from Frenot *et al.*, 2005); tentative North American report by Smith (1917: 177) - see Stöp-Bowitz (1969)].

subrubicundus (Eisen, 1873/4: 51). Rosy to deep red, tail tip yellow. Body cylindrical or more or less flattened. Tubercula well developed, oval extending though 27,28-30. Tumescences around ab present (Michaelsen) or absent (Gerard) on 16, sometimes on 9, 17, 19, 22-35. **Spermathecal pores present** in 9/10/11 in c lines. Chromosome number 4n=68 in UK; 2n=34 in Italy. Facultatively parthenogenetic.

There is some conflict in these diagnoses and in the description by Sims & Gerard (1985, 1999: 77, fig 24) as their *subrubicundus* morph is shown with broad tubercula pubertatis in 28-30 and tumescences around setae ab on 16 (and 26-32); while their *rubidus* / *tenuis* morph has narrow bands in only 29 and 30 but no setal tumescences. In contrast, Gates (1972: 95) simply differentiates *rubidus* 'typica' morphs with tubercula restricted to 29-30 from *subrubicunda* morphs with tubercula extending 28-30; and he defines both the *consticta* and *tenuis* morphs as athecal. Easton's (1983) inclusion of *constricta* in synonymy of *D. rubidus rubidus* implies this morph sometimes lacks spermathecae and it is thus possible that *constricta* more appropriately belongs in same synonymy as the *tenuis* morph. Bøgh (1993) indicated that the *subrubicundus* morph (at least?) may merit specific status. Characters of current specimens overlap, but all appear to lack spermathecae (i.e., = *rubidus*/*tenuis*)].

Table of characters of putative *Dendrodrilus rubidus* sp-complex *

Species	**Clitellum**	**TP**	**Sem. Ves.**	**Spermathecae**	**Tail**
Dd. r. rubidus	25,26,27-31,32	(28)29-30(31)	9,11,12	9/10/11 in c lines (absent in *constrica* synonym?)	?
(*Dd. r. tenuis*)	(25)26-31(32)	(absent, or on 28,29-30,31)	(11,12)	(**often absent or incomplete**)	yellow
Dd. r. subrubicundus	(25)26,27-31,32	28-30(31)	9,11,12	9/10/11 in c lines	yellow or not?
Dd. r. norvegicus	25,26-32	28,29-30,31 or 28-29	11,12	9/10/11 in c lines	?

*After Stöp-Bowitz (1969) and Csuzdi & Zicsi (2003: 131, Tab. 6.4) for Hungarian spp. and pers. obs.; cf Sims & Gerard (1985) as noted above. Note: Csuzdi & Zicsi (2003) call *tenuis* a parthenogenetic form and list TPs as absent; perhaps it belongs in *D. rubidus* synonymy. However, it has page priority over Eisen's other sub-species and may be retained, at least as a morphological variety (strictly illegitimate by ICZN).

Genus ***Eisenia*** Malm, 1877

Eisenia Malm, 1877: 45.

Note: Genus attributed to August Wilhelm Malm (1821-1882) of Götebourg, Sweden not Anders J. Malmgren (1834-1897) of Finland who is abbreviated as "Malm.".

[Syn.: *Endrilus?* (laps.?) Smith, 1887; *Allolobophora* (*Notogama*) Rosa, 1893 (type-species: *Enterion fetidum* Savigny, 1826)].

Type-species: *Enterion fetidum* Savigny, 1826.

Diagnosis: Calciferous glands, without sacs, opening directly into the oesophagus in 11, and/or 12 through a circumferential circle of small pores (e.g. in *fetida*). Nephridial vesicles sausage-shaped or digitiform. Nephropores inconspicuous, alternate irregularly on each side of the body above b and d lines. Pigment red, variable (or unpigmented, e.g. *E. japonica*). Hearts in 7-11. Setae closely paired. Spermathecal pores dorsal. Dorsal pores from the region of 4/5/6. Prostomium epilobous (but may sometimes appear tanylobous, e.g. in *E. fetida* and *E. japonica*).

Basic chromosome number for *Eisenia* is given as 2n=22 by Gerard (1964: 25).

Taxonomic Note: After Easton (1983), *Bimastos longicinctus* Smith & Gittings, 1915 was transferred to *Eisenia* – although this change is now reversed – and *hortensis* and *veneta* were removed to *Dendrobaena*.

Distribution: Palaearctic. Approximately 30 included species, a few taxa are widely distributed, especially the type, *E. fetida*, that has been transported accidentally and sometimes deliberately (e.g. for vermiculturing and biotoxicological assay). *Eisenia fetida* forms a species-complex and its possible synonyms are *E. nordenskioldi* (Eisen, 1879) [sometimes misspelled "*nordenskjöldii*", "*nordenskioldii*", "*nordenskioeldi*" or "*nördenskiöldi*" the latter consistently by Qiu & Bouche (1989: 189)], once mistakenly reported from the Azores (Michaelsen, 1900) but also reported from Hawaii (e.g. Beddard, 1912: 111 see http://www.regenwurm.de/pdf/beddard-earthworms.pdf), and *E. andrei* Bouché, 1972 (see Remarks below). *Eisenia pearsei* Stephenson 1932(/3?) from Durham, North Carolina was known only from the original description and is now in synonymy of USA native *Eisenoides carolinensis* (Michaelsen, 1910) – see Blakemore (2005; 2007) and entry below. *Eisenia lucens* (Waga, 1857) [syns. *submontanus* Vejdovsky, 1875; *foetida hungarica* Örley, 1881; *tigrina* Rosa, 1896; *latens* Cognetti, 1902; *rosea croatica* Szuts, 1909; *gavrilovi* Cernosvitov, 1942; although Perel (1979) cites the *submontana* synonym as valid] is reported from São Francisco de Paula, Brazil by Knäpper & Porto (1979).

Remarks: Whereas Michaelsen (1900) first placed *rosea, hortensis* and *veneta* in *Eisenia*, primarily because the dorsal location of spermathecal pores agreed with the

type-species, Gates (1972: 96) deduced that *rosea* was anomalous (and he proposed a generic definition to accommodate it), yet he still allowed all three names in *Eisenia*. Later, (Gates, 1976) transferred *rosea* to *Aporrectodea* and, more recently, Easton (1983) shifted *hortensis* and *veneta* to *Dendrobaena* - a preferable option, inexplicably ignored by Sims & Gerard (1985; 1999) who allowed both to linger uneasily in *Eisenia*, somewhat invalidating their generic definitions (on which the above diagnosis is based). *Eisenia japonica* is retained in the genus as per Easton (1981, 1983).

Eisenia anzac Blakemore, 2011

Fig. 6.13a *Eisenia anzac* Holotype – original sketch.

For details, see Blakemore (2011, 2019) and Blakemore, R.J. 2018. *Eisenia anzac*. The IUCN Red List of Threatened Species 2018: e.T117372657A135692298. https://dx.doi.org/10.2305/IUCN.UK.2018-1.RLTS.T117372657A117374393.en.

Distribution: Commonwealth Cemetery, Yokohama (collected in 2010) and from Shrine near Lake Biwa (collected in 2011) the latter differing on primary COI barcode analysis by about 4% so possibly there is some evidence of genetic drift in a native population. This difference probably justifies a new sub-species and the name "*Eisenia anzac monax*" is informally proposed, simply because the specimen was collected on Groundhog Day (2nd Feb., 2011). *Eisenia anzac* and *E. japonica* sub-sp. have recently been located on Taiwan (see Sherlock et al. 2018 - https://www.tesri.gov.tw/Uploads/userfile/A15_2/2019-03-14_1604252449.pdf ; accessed 13th December, 2020). These authors provided no DNA support.

DNA: BLAST comparison of mitocondrial COI gene results (from iBOL submission JET174-11 (submitted by RJB April, 2011) – this the first Japanese earthworm holotype to be simultaneously barcoded) showed greatest similarity (but just ca. 84%) with two named "GENBANK species":-

1. **Bimastus parvus** [sic] voucher 06-277 by Huang et. al. (2007) "Identifying earthworms through DNA barcodes" Pedobiologia (Jena) 51 (4), 301-309.
2. **Eisenia eiseni** [sic] voucher MPLe0001by Perez-Losada et al. (2005). "Phylogenetic species delimitation of the earthworms Eisenia fetida (Savigny, 1826) and Eisenia andrei Bouch, 1972 (Oligochaeta, Lumbricidae) based on mitochondrial and nuclear DNA sequences". Pedobiologia (Jena) 49 (4), 317-324.

Neither *Bimastos parvus* nor *Allolobophoridella eiseni* comply morphologically and both the above misattributed and **bolded** "names" may be misidentified – again

questioning the reliability of publications in *Pedobiologia* and GenBank. Other presently un-barcoded yet properly identified species may be found that comply and the question remains open as to whether *E. anzac* is a Japanese native or an exotic introduction – hence its listing in this Cosmopolitan Earthworms publication.

>JET174-11|HNHM-15529|***Eisenia anzac*** Holotype from Japan, H|COI-5P
AACTTTATATTTTATTCTCGGTGTTTGAGCTGGTATAGTTGGTGCCGGTATA
AGACTTCTAATTCGAATTGAACTAAGACAGCCGGGAGCCTTCCTAGGAAGA
GATCAACTATACAATACAATTGTAACAGCTCATGCATTTGTTATAATTTTCT
TTTTAGTAATACCTGTATTTATTGGGGGATTTGGAAATTGATTACTTCCCCT
AATACTAGGAGCCCCTGACATAGCCTTCCCACGACTAAACAATATAAGATT
CTGGTTACTTCCCCCGTCACTTATCCTCTTAGTATCTTCCGCTGCTGTAGAAA
AAGGTGCAGGTACAGGATGAACAGTATACCCCCCCTTATCAAGAAACCTTG
CACATGCAGGTCCATCAGTAGATTTAGCCATCTTTTCTCTTCACCTGGCAGG
AGCTTCTTCAATTCTGGGAGCTATTAACTTTATCACCACAGTTATCAACATA
CGTTGAAGAGGATTACGACTAGAACGAATTCCCCTATTTGTATGAGCTGTA
GTTATTACAGTAGTCCTACTTCTTCTATCCCTCCCAGTGCTCGCAGGAGCCA
TTACCATGCTACTTACAGATCGAAACTTAAATACTTCATTTTTCGACCCTGC
CGGTGGTGGAGACCCTATCCTATACCAACATCTTTTC

BLAST result Dec., 2020: <95% for "*Lumbridicae*" from Niigata LC200155, also from "Tochigi, Nikko" and "Nagano, Kijimadaira" suggesting a closely related species complex in Japan (at least).

Eisenia fetida species-complex

[*Eisenia fetida* is the representative taxon with all its progressive synonyms].

Eisenia fetida (Savigny, 1826)

Fig. 6.14a *Eisenia fetida* ex Brisbane wormfarm ventral view and dorsal view of prostomium.
Fig. 6.14b *Eisenia fetida* from Japanese culture, labeled dissection photograph.
Fig. 6.14c A: *Eisenia fetida* specimen S1 from Jeju Isl., Korea; anterio-ventral and lateral views, dorsal prostomium; spermathecae and calciferous glands *in situ*, nephridium from 20lhs. B: *E. fetida* S3 ditto with nephridium in 13lhs. C:

Athecal *Allolobophora hataii* Kobayashi, 1940: fig. 5 (*incertae sedis*) for comparison [from Blakemore (2013: fig. 1)].

Enterion fetidum Savigny, 1826: 182. [Type locality Paris. Types in Paris Museum]; Reynolds & Cook, 1976: 101 (corr. *foetidum* illegal emendation).

Lumbricus semifasciatus Burmeister, 1835: 33, figs. 3a-c. [Types? Non *Amynthas semifasciatus* Michaelsen, 1899 from Celebes].

Lumbricus annularis Templeton, 1836: 234. [Types missing].

?*Lumbricus xanthurus* Templeton, 1836: 235.). [From Ireland. Types missing. "*Of a bright red, the apical rings yellow. This is the gult-tail of anglers, and is found among rotting oak bark, in old hot-beds and melon frames*."; Johnston, 1865: 62 ("*Apparently some slight variety of L. foetidus*". Restoration as a senior synonym of *E. fetida andrei* suggested by Blakemore (2013: 64), Blakemore & Lee (2013). Cf. its listing as a possible synonym of *D. rubidus*].

Lumbricus foetidus: Dugès, 1837: 21 [illegal emendation]; Johnston, 1865: 61; Eisen, 1871: 960.

Lumbricus olidus Hoffmeister, 1842: 24, figs. 1-5, 15, 28a,b, 30. [From neighborhood of Berlin. Types missing]; Hoffmeister, 1843: 190 fig. 5; 1845: 32, figs. 5a, b (part?).

Lumbricus luteus Blanchard, 1849: 42. Non *Lumbricus communis luteus* Hoffmeister, 1845. [From Chile. Types missing].

Lumbricus rubrofasciatus Baird, 1873: 97. [From St. Helena. Types?]. [Originally spelt *Rubro-Fasciatus* which translates as "Red Banded" (= *Eisenia fetida*?).

?*Allolobophora nordenskiöldi* Eisen, 1879: 6, 46. [Type locality Siberia? Types in Stockholm, 110 and Hamburg, 3519]. [Also spelt "*nordenskiöldii*" by Eisen (1879: 46); this synonym not acceptable to some authors - see Notes below].

Allolobophora foetida: Eisen, 1874: 50.

Lumbricus annulatus Hutton, 1876/7: 352. [From Dunedin, New Zealand - see Benham, 1898 when material was in the Otago Museum; syntype now in BMNH: "*1886:11:18:14 Loc: DUNEDIN N.Z. Coll: OTAGO UNIVERSITY MUSEUM Ref:..*" with old Otago label "*6:11:18:14*"; one mature specimen in good condition tied to a film – dark with possibly lighter intersegments and paler in 9-11; clitellum 26-32 and TPs in 28-30,31½]. [Non *annulatus* Perel, 1975: 995 (= *L. polyphemus*)].

Allolobophora foetida var. *fimetoria* Örley, 1881: 598. [Type in Holland, RNHL, 1725]. [Misspelt "*fimetora*" by Csuzdi & Zicsi (2003: 143); non *Eisenia fimetorum* Fitzinger, 1833: 552].

[Note: *Allolobophora foetida* var. *hungarica* Örley, 1881: 561 = *Eisenia lucens*].

Endrilus? annulatus: Smith, 1887: 136 [err. Non *Eodrilus* Michaelsen, 1907 nec *Eudrilus* Perrier, 1871].

Allolobophora sp. (*Lumbricus ruber* Boeck in MS + *Lumbricus costatus* Grube in MS - *nomina nuda*?); Michaelsen, 1892: 212.

Allolobophora (*Notogama*) *foetida*: Rosa, 1893: 424.

Eisenia foetida: Michaelsen, 1900: 475 (syns. *semifasciatus*, *annularis*, *olidus*, *luteus*, *rubro-fasciatus*, *annulatus*); Tétry, 1937: 143; Gates, 1943: 95; Lee, 1959: 361 (syn. *annulatus*); Gerard, 1964: 26; Gates, 1972: 97-103 [syn. ?*nordensköldi* (Eisen, 1879)]; Reynolds & Cook, 1976: 103; Reynolds, 1977: 74, fig. 22 (syn. *semifaciatus*, *annularis*, *olidus*, ?*luteus*, ?*rubro-fasciatus*, *annulatus*, *foetida* var. *unicolor*, *fetida andrei*).

Eisenia nordenskiöldi caucasica Michaelsen, 1903: 38. [From Transcaucases, up to 2500m altitude, and also in association with *E. fetida* (see Michaelsen, 1903: 39). Types in Hamburg: 6959 according to Reynolds & Cook, 1976: 85 for their probable misspelling as "*caneasia*" (= *Ei. nordenskioldi caucasica*), although Michaelsen has them in St. Petersberg Museum]. [Non *caucasica* Kulagin, 1889: (= *D. veneta*) listed by Reynolds & Cook (1976: 86), cf. '*Ei. nordenskjöldi caneasia* Mich, 1907: 82' (sic, laps. pro *caucasica*) Reynolds & Cook (1976: 85) although my attempts to access this 1907 Georgian publication were unsuccessful].

Helodrilus (Eisenia) foetidus: Michaelsen, 1913: 551.

Eisenia foetida attica Tzelepe, 1943: 1. [Types?]. [Misspelt as "athica" by Reynolds & Cook (1976: 73)].

Eisenia fasciata Backlund, 1948: 1. [From Sweden. Type in Lund]. [From "*fasciatus*" meaning banded. Apparently retained as valid species by some authors, e.g. Stöp-Bowitz (1969: 260, Table V) but without justification].

Eisenia foetida var. *unicolor* André, 1963: 1. [Types?]. [As varietal names proposed after 1961 were regarded as outside of ICZN nomenclature (ICZN: At. 15), this invalid name was replaced by Bouché (1972) as *fetida andrei* however, several other synonyms of *E. fetida*, if re-evaluated from types, would seem to take

priority].

Eisenia fetida andrei Bouché, 1972: 381. [Type locality? Types in Sully, France OECO 79-1388-4321]. [Name sometimes misspelt "anderi"]; Jaenike, 1982: 6.

Eisenia unicolor: Øien & Stenersen, 1984: 277. [Name apparently subordinate to *E. fetida andrei* that takes priority, but possibly not a true synonym].

Eisenia andrei: Sims & Gerard, 1985; 1999: 79 (syns. *foetida* var. *unicolor*, *fetida andrei*, *unicolor* Øien & Stenersen, 1984). [Citation of *unicolor* Øien & Stenersen, 1984 without a colon (:) as a synonym is possibly a mistake by Sims & Gerard as this name may just be an elevation to species level by those authors rather than a newly proposed name by Øien & Stenersen].

Eisenia fetida: Stöp-Bowitz, 1969: 177, 210 (syns. *foetidus, olidus*); Easton, 1983: 480 [syns. *foetida* auctorum (illegal emendation), *semifasciatus*, *annularis*, *olidus*, *luteus*, *rubofasciatus*, *annulatus*, *fetida fimetoria* Örley, 1881, *nordenskioeldi caucasica* Michaelsen, 1903, *fetida attica* Tzelepe, 1943, *fasciata* Backlund, 1948, *fetida* var. *unicolor, fetida andrei*); Sims & Gerard, 1985; 1999: 80, figs. 25, 26 [their artist has clitellum in wrong position in fig. 25] (syns. *fetidum, foetida, fetida fetida*: Bouché, 1972); Csuzdi & Zicsi, 2003: 143 [syns. *semifasciatus, annularis, olidus, luteus, rubro-fasciatus, annulatus, foetida fimetora* (laps. pro *fimetoria*), *nordenskiöldi caucasica, foetida attica, foetida unicolor, fetida andrei*]; Blakemore, 2004; 2005 (syns. *foetida*: Michaelsen, 1900 (illegal emendation); *semifasciatus* Burmeister, 1835; *annularis* Templeton, 1836; *olidus* Hoffmeister, 1842; *luteus* Blanchard, 1849; *rubofasciatus* Baird, 1873; *annulatus* Hutton, 1877; *ruber* Boeck, 1892 (?nom. nud.); *costatus* Grube, 1892 (?nom. nud.); *fetida fimetoria* Örley, 1881 [non *fimetorum* Fitzinger, 1833]; *nordenskioldi caucasica* Michaelsen, 1903; *fetida attica* Tzelepe, 1943 [misspelt as "athica" by Reynolds & Cook (1976: 73)]; *fasciata* Backlund, 1948; *fetida andrei* Bouché, 1972 nom. nov. pro *E. fetida* var. *unicolor* André, 1963; ?*unicolor*: Øien & Stenersen, 1984): Blakemore, 2004; 2006; 2007; 2008; 2010: 656 (syns. as above).

Eisenia fetida fetida : Bouché, 1972: 380.

Eisenia andrei andrei : Qiu & Bouché, 1998: 189. [Probably another mistake as these authors do not provide names of any other *andrei* sub-species].

Taxonomic Notes: Still often incorrectly cited as "*foetida*". References to taxa variously called "*Eisenia foetida f. californica*" or "*Eisenia fetida californica*" seem to be

unauthored infrasubspecifics or *nomina nuda* and are thus invalid names.

Recent publications (see synonymy above) cite *E. andrei* Bouché, 1972 as either a synonym, morph, 'variety', sub-species, or as a separate species; however, several prior synonyms of *E. fetida* may compete for priority if thoroughly checked against types. Recently, Csuzdi & Zicsi (2003: 143) considered *andrei* in synonymy of *fetida* as does Csuzdi (2012) and Blakemore (2012). Moreover, *E. nordenskioldi* is also debatably at least part in synonymy of *E. fetida*, or has been so associated in the past, as were several of Kobayashi's (1940) taxa (see Blakemore, 2013). Thus, rather obviously, it seems that *E. fetida* may yet comprise several separate species or subspecies (e.g. Perez-Losada *et al.*, 2005) for which many available names occur in its synonymy that will compete for priority if ICZN (1999) is correctly applied by competent taxonomists rather than by such 'taxonomic tourists'.

For example, Johnston (1865: 62) for *L. xanthurus* Templeton says it is "*of a bright red, the apical* [caudal?] *rings yellow*" and known in the vernacular as "Yellow-tailes", "Gilt-tail" or "Tag-worm" [Day worm?] and it found in rotten bark or "*in old hot-beds and melon frames*". He concludes: "*Apparently some slight variety of L. foetidus*." This assertion has yet to be disproven, especially since the *andrei* entity is also claimed to be a bright red colour. Blakmore (2013: 64) and Blakemore & Lee (2013: 127) mooted restoration of *Eisenia xanthura* (Templeton, 1836) priority over *E. andrei* or other subsequent synynyms of *E. fetida* species-complex *sensu* Blakemore, 2002.

Moreover, Stop-Bowitz (1969, tab. V) at least maintains Scandinavian *E. fasciata* Backlund, 1948 which is often included in *E. fetida* synonymy by some authors along with 14-15 other names, but more often than not (especially in chemical/molecular studies) these available synonyms are completely overlooked (see discussion in Blakemore et al. 2010 and further discussion in **Remarks** below).

Diagnosis: Length 27-130 mm. Colour variable, from claret or deep chestnut brown to paler pink dorsally, buff ventrally and intersegmentally giving a banded appearance, or uniform red; yellow tip to tail due to accumulation of coelomocytes. Body cylindrical or flattened. Prostomium epilobous. First dorsal pore 3/4/5/6. Spermathecal pores in 9/10/11 dorsally. Male tumescences confined to 15. Clitellum 24,25,26,27-31,32,33,34. Tubercula pubertatis solid ridges lateral to b lines, variable but usually on 28-30. Tumescences around ventral and lateral setal couples in some of 8-13 and occasionally 17-23, and around ab only in any of 17-35 – most often some of 22-24 and 27-34. Setae closely paired (aa=bc, dd=0.5 U). Seminal vesicles in 9-12. Ca. glands in 10-12.

Distribution: Originally of Eurasian origin now cosmopolitan; commonly bred in worm farms around the world and sold as : "*Tiger worms*", "*Red wrigglers*", or "*Red worms*" [hence confusion with *L. rubellus* that is also colloquially named "*Red Worm*"], known to anglers as "*The Brandling*", although it is reported as distasteful to some fish. This species is sometimes classed as 'haemerobiont' (entirely dependent on culture – Julin, 1949: 51), however, it is recorded from a range of habitats around the world such as taiga, forests and steppes in Russia and Siberia; from Greenland, Iceland [in a hot spring – Backlund, 1949: 3)], Svalbad [= Spitzbergen, as the only earthworm species recorded from there until Coulson *et al*. (2013a,b) recorded two species, *Dendrodrilus rubidus* (Savigny, 1826) and *Dendrobaena hortensis* (Michaelsen, 1890), in anthropogenic manured soils below the abandoned cowsheds in Barentsburg) and Faeroes (Omodeo, 1963: 146; Gates, 1972: 98); one of the commonest worms of the Himalayas, e.g. from the bed of hill stream Darjeeling, 7,000 ft from Mt Everest Expedition (Stephenson, 1925: 906); Siberia, the Crimea and Transcaucasia (sympatrically with *E. nordenskioldi* – Michaelsen, 1903), W. Turkestan, and Hokkaido (Stöp-Bowitz, 1969: 213); under manure piles and in gardens in ACT, Australia and NZ (pers. obs.); under pastures in New Zealand (Lee, 1959) and in organic compost near Lake Biwa, Japan (pers. obs.).

Gates (1972) reported that repeated attempts to introduce *Eisenia fetida* to tropical lowlands are known to have failed and that it was absent from Myanmar. However, Stöp-Bowitz (1969: 213) reports it from USA, Mexico and South America (e.g. Ecquador, Chile, Peru, Argtentina, Brazil, Colombia, Paraguay, Uruguay, Venequela, Bermudas, South Africa, India, Nicobar Isles, Australian, New Zealand, Hawaii, Iberian and Italian peninsulas, Azores, Madeira, and the Canary Islands; and, moreover, Csuzdi & Pavlicek (2005a: 91; 2005b: 71) recently report it from Mar Saba and Samaria, Israel and Jordan. Thus *E. fetida* is already known from Brazil and Dr G. Brown (pers. claim. April, 2011) that only "*E. andrei*" occurs from the whole of Brazil is obviously erroneous and based on incompetent and compromised scientific identification.

Certainly *E. fetida* survives in wormfarms in subtropical Queensland (pers. obs.) and recently there was a report of its utilization at the University of Tropical Agriculture, Phnom Penh, Cambodia. Previously recorded from Australia, e.g. by Fletcher (1886, 1890), Jackson (1931). This report confirms occurrence in Australia in Qld, NSW, SA, ACT, and Tas.; as well as Taiwan and Japan. It was found in a well watered gardens in O'Connor, Canberra, ACT, in Shingu-jinja, Omihachiman Shiga-ken and in Grafton, Auckland, NZ. In these places I found it free-living away from culture beds/compost in

well-mulched and watered gardens, and at Lake Biwa, Japan it was in the crook of a deciduous tree buttress in a shrine garden.

Recent studies in China have found it to be effective in restoration of saline soils when used in combination with municipal composts (Ref.).

Apparently a 1999 application to import it to Philippines was defered (Ref.) thus it is not yet known from that country where *Eudrilus eugeniae* reigns (pers. obs.). For an earlier record or *E. fetida* from Bali (Indonesia), I can no longer find the original source although this is one of the species reported from vermiculture in Java [e.g. by Bintoro Gunadi (2010) www.crcnetbase.com/doi/abs/10.1201/b10453-31].

Locality: Qld: Brisbane, Mackay (collector F. Clarke); NSW: Bradbury, Budderoo and Menai; Canberra; Tasmania: from wormfarms at Launceston, Perth (Tas.), Hobart, etc.; Japan (e.g. specimens seen 24.VII.2002); sold throughout Japan as fishing bait worms from Kyushu (pers. obs. 11.IX.2001); collected from compost heap at University of Shiga-ken campus at Hikone and at Shingu-jinja, Shimotoyoura, Azuchi-cho, Omihachiman (these latter Shiga- ken specimens in Lake Biwa Museum collection); an Auckland garden and seen in Mokai Thermal glasshouse exterior worm bedrows, Taupo, New Zealand.

Habitat: Worm beds, composts, and organic garden or farm soils; under logs and on vegetables; woodlands in wet litter [e.g. dominant in forest litters on Raoul Island and also in fairly warm soil under a cover of moss growing close to a fumarole in the main crater (Lee, 1959) along with *Acanthodrilus kermadecensis* in hot soil].

Temperature/moisture tolerance: Range is remarkable from Subartic Spitsbergen to subtropical Kermadecs in hot soil. Also reported by Backlund (1949) from a hot spring in Iceland; and found in Taiga, forest and steppes in Russia / Siberia and on snow in winter (Stöp-Bowitz, 1969: 214); Gates (1967: 157) reported it from Southern California, Arizona and other desert states; plus Israel (Ref.). It has an experimental temperature range of -2 to +40 °C (from Lee, 1985, Tab. 2), can survive loss of 61.6% of its body moisture (Schmidt, 1917; Grant, 1955), and is reported to survive total water immersion for periods up to 6 months (Gates, 1972: 100). A 2015 China study has used it for restoration of saline soils (Ref.), thus it seems somewhat salt tolerant.

Human parasitism (?): Gates (1972:103) cites a report from Italy of *E. fetida* passed in the urine from the urethra of a female patient. From Japan there is an obscure report of a male farmer supposedly coughing up a dozen or so *Eisenia fetida* with (bloody?) phlegm over the course of 3 days, and thus interpreted as a likely case of lung

parasitism [Ryujin, M. (1952). Case report on a parasitism of earthworms in human. *Japanese Journal of Sanitary Zoology* **3(3&4):** 98-99 (in Japanese - translation by M. Grygier pers. comm. March, 2007)]. Other accidental parasitic reports are listed by Blakemore *et al.* (2012).

Behaviour: Ejects yellow coelomic fluid if agitated with distinctive 'nutty' smell; cocoons supposedly deposited near surface (August-December in northern hemisphere?). An accomplished climber – found on moist house wall 5-6m above ground (Stöp-Bowitz. 1996: 214). Often found on plastic container walls of compost (anaerobic, acidic?).

Length: 27-130 mm.

Width: 2-6 mm.

Segments: (65) 100 (±30). Body cylindrical, often becoming trapezoidal posteriorly.

Colour: Variable, from deep claret or chestnut brown to paler pink dorsally with iridescence, buff ventrally and intersegmentally giving a banded appearence; or uniform red; posterior tail segments often bright yellow due to coelomocytic inclusions; clitellum paler or darker. [See further comments on colouration in Remarks below].

Prostomium: Open epilobous, sometimes tending to tanylobous.

First dorsal pore: 3/4/5/6, usually 4/5.

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired; (4:1:3-4:1:15-16:ca. 0.5). Setae need to be checked as closely paired to compare to widely in *D. veneta*.

Nephropores: Inconspicuous, alternate irregularly on each side above b and d lines.

Clitellum: Saddle-shaped, variable 24,25,26,27-32,33,34 (i.e., on six to eight segments).

Male pores: Equatorial slits, almost lateral and confined to 15 in either large or only slightly raised tumescences.

Female pores: Minute, just lateral to b in 14.

Spermathecal pores: Paired 9/10 and 10/11 well above d lines nearer mid-dorsum.

Genital markings: Tubercula pubertatis solid ridges lateral to b lines, variable in 27,28,½28-30,½31,31,½32,32 i.e., on three to six segments, but usually 28-30 and only just impinging on adjacent segments; tumescences around either or both the ventral and lateral setal couples in some of 8-13 and occasionally 17-23, and around ab only in any of 17-35 - most often in some of 22-24 and 27-34 (Gates, 1972; Sims & Gerard).

Septa: None thickly muscular.

Hearts: 7-11.

Gizzard: In 17-18.

Calciferous glands: Without sacs, glands intramural widening in 10-12 then narrowing

in 13-14; opening into gut in 11 (or 12, Gates).

Intestine origin (caeca, typhlosole): Variously taken as either before gizzard in 15 (e.g. Gates, 1972:97), or afterwards in ca. 20; typhlosole beginning in 20-23.

Nephridia: Holoic with sausage-shaped or digitiform bladders.

Male organs: Testes/funnels 10 and 11, seminal vesicles 9-12.

Ovaries: Small in 13.

Prostates: None.

Spermathecae: Two small pairs in 9 and 10, spherical ampullae, adiverticulate.

Gut contents: Fine soil and organic material.

Cocoons: Lemon-shaped 2.4-5.2 mm long by 2.3-4.4 mm wide, yellow but darkening with age.

Notes: Spermatophores have been stated to be reliable indicators of copulation (Monroy *et al.*, 2004). In a cocoon eight to twenty embryos may be present but most consumed by dominant embryos and, after incubation of about 3-11 weeks, only one to five hatchling emerge but usually the number is two. Maturity takes 15-74 weeks. Reproduction is described as biparental or rarely 'facultatively self-fertilizing', true parthenogenesis has not been proven although is possible (Gates, 1972:98; Sims, 1983: 472; Sims & Gerard, 1985; 1999). Muldal's (1948: 21) report of interspecific hybrids for *A. rosea*, *E. fetida* and *D. veneta* were considered false by Gates (1972:107). Regeneration is possible anteriorly from 23/24 and posteriorly from 20/21 (Gates, 1972 – see also http://www.biolbull.org/cgi/reprint/99/3/425.pdf).

An interesting finding by Miles (1963) was that when *Eisenia fetida* was cultured in sterile soil to which soil fungi and bacteria were added, specimens failed to grow, but when soil protozoa were added, the worms grew to maturity.

Other data from Gates (1972) are that specimens have survived total immersion for periods up to 6 months; maximum life expectancy has been found to be 5 years, but average life span is 503-594 days depending on temperature; food passes through the gut in 8-15 hours; in Pakistan, a population of 1,000 increased to 456,380 in about six months. Parasites include ciliates, sporozoans, cestodes, nematodes and one dipteran - as listed by Gates (1972:102).

Eisenia fetida is the species most often used in vermiculture and vermicomposting operations, from the sub-arctic to the sub-tropics, e.g. for stabilizing sewage sludge, piggery effluent, and other organic materials. It is also used as a protein supplement, e.g. in the diet of pigs, fowl and fish. Laboratory cutures are maintained for

ecotoxicological (e.g. Bouché, 1984) and various other studies. Earthworms are selected by organizations such as EEC and OECD for chemical toxicity testing, and they usually specify either *E. fetida* and/or *E. andrei* as the test organism but do not usually provide a means to separate these taxa (cf. *D. veneta* that is often erronsously supplied instead). Results from such studies are not usually representative of what occurs in the field as this species is quite anomalous in its ecology and behaviour.

Remarks: Variations, particularly with respect to colouration are common. Gates (1943: 95) described "*Johns Hopkins*" and Dr Oliver's "*Soilution*" worms that appeared to have uniform red pigmentation (i.e., without obvious intersegmental paleness), faint stripes or with conspicuous striping. Lady Eve Balfour (*Mother Earth* Spring 1948: 13) says these worms, claimed as hybrids by "Dr Olvier", she was finally convinced were actually just parthenogenetic *E. fetida*. It was later stated by Gates (1972: 103) that, despite claims by wormgrowers, true hybrids have not been proven and, although banded forms were cross bred with unicolored French worms, these F1 hybrids were sterile. Dominguez *et al.* (2003: 530, Plate 1) found that successful self-fertilization, or "*autofecundation*" occurred rarely in a high density population of *E. fetida*, but these authors question whether parthenogenesis is possible. According to Gerard (1964:26) chromosome number of *E. fetida* is 2n=22 (in UK population?).

In recent publications (see synonymy above), ***E. fetida andrei*** Bouché, 1972 is cited as either a synonym, morph, 'variety', sub-species, or as a separate species. It is supposedly recorded from low pH and laboratory cultures of *E. fetida*, but differs imperceptibly from *E. fetida* as specimens of *E. andrei* sometimes vary in their colouration too (see also Reinecke & Kriel, 1981; Reinecke & Venter 1987). These two entities then are 'molecular taxa' that can surely be differentiated only by using enzymic gel electrophoresis (Jaenike, 1982; Øien & Stenersen, 1984; Engelstad & Stenersen, 1991; Reinecke & Vijoen, 1991), but **only** once the types confirm this. But, the starting point for Jaenike's study was a greenhouse population maintained by Dr Roy Hartenstein at the SUNY Syracuse campus from founding stocks initially procured from a number of bait dealers obtained from "*all over*", and supposed to consist of striped (*fetida*) and unstriped (*andrei*) vouchers that were deposited in American Museum of Natural History (No.s 4033 and 4034, respectively). New evidence from France (Albani *et al.*, 2003) claims to differentiate the taxa by luminecence of coelomic fluids from *E. andrei* but their starting point is their own

laboratory cultures and they did not attempt to confirm differentiation of taxa by electrophoresis nor with reference to types. Recently, Dominguez *et al.* (2005) purported to show "*reproductive isolation between* E. andrei *and* E. fetida*; they can therefore be considered distinct biological species with different life histories*." However, the starting point, even for this study, was Spanish and Brazilian populations that were not differentiated by molecular, electrophoretic nor morphological analysis – presumably only striped or non-striped superficial colouration was used as the determinant, and this seems to be supported from recent comments by Dr G. Brown where he flatly stated that only *E. andrei* is found in Brazil, but without any supporting evidence (pers. com. April, 2011). Similarly with the study by Perez-Losada *et al.* (2005). In another example, Cech *et al.* (2005: 95) say that a recent molecular analysis of "Eisenia andrei ... *is most likely a misidentification error and actually Erseus & Kallersjo (2004) used in their analysis a specimen of* Dd. subrubicundus" – but this identity too must be speculation without comparison with types. And so it goes on....

Moreover – as explained by by the current author in the current publications at IOTM conferences and, for example, in Blakemore *et al.* (2010) and by Blakemore (2013) – *E. andrei* yields priority to about a dozen prior *E. fetida* synonyms,. However, it is also possible that more than just one *E. fetida* 'variety' is involved (as inadvertently suggested in an ungrounded touristic study by Perez-Losada *et al.*, 2005). As yet, to the best of my knowledge, morphological or molecular analysis of actual type materials of all the *E. fetida* species-group (or synonyms) has never been attempted.

For example, Gates (1972: 103), from inspection of previously identified specimens (not types), found ***Eisenia nordenskioldi*** (Eisen, 1879) distinguishable from *E. fetida* only by its greater number of atyphlosolate segments at the hind end of the body, although this character varies in *E. fetida*, with between 8-22 ultimate segments atyphlosolate (Gates, 1972: 101), indeed, *E. nordenskioldi caucasica* Michaelsen, 1903 is in synonymy. Moreover, *E. nordenskioldi* too is said to vary intraspecifically regarding presence of absence of pigmentation (Perel, 1979: 635). Because of this uncertainty, an ***Eisenia nordenskioldi*** **species-complex** is briefly described below (with explanation of correct orthography of specific name).

DNA: Details of some examples may be found in Blakemore (2013).

Eisenia japonica japonica (Michaelsen, 1892)

Fig. 6.15a1 *Eisenia japonica* a syntype from Berlin #2117.

Fig. 6.15a2 *Eisenia japonica* a syntype from Berlin #2117.

Fig. 6.15b *Eisenia japonica* a syntypes Hamburg V119 + V121.

Fig. 6.15c *Eisenia japonica* a topotype specimen from Enoshima.

Fig. 6.15d *Eisenia japonica* specimen from Hodogaya (NSMT An-415).

Fig. 6.15e *Eisenia japonica* from Hachioji, western Tokyo, Japan - labeled photograph.

Allolobophora japonica Michaelsen, [1891: 6?], 1892: 230; Beddard, 1895: 715. [Type locality Japan ("*Enosima*" = Enoshima near Yokohama plus "*Hakodate*" in Hokkaido) and Michaelsen (1900) later added "*Fusi-jama*" = Mt. Fuji, then (in 1910) Yokohama. Michaelsen (1892: 232) inspected material in the Zoological Museum, Berlin: No. 2117 from Enoshima collected by Hilgendorf on 29.III.1875, and larger but less well preserved specimens from Hakodate No. 2115 part of the "*Fischerei-Ausstellung*" (a German Exhibition to promote consumption of fish as held in Berlin in 1880 and 1896?) with Spec. Kat. No. 469; these specimens were listed by Hartwich & Kilias (1989: 268) as 2115 from Hakodate (with all syntypes lost, one after exchange with Dr D Rosa in Turin Museum on 16.I.1893), and 2117 from Enoshima (8 syntypes); Reynolds & Cook (1976: 120) additionally list types in Hamburg: 119-122 as well as in Berlin: 2117, perhaps from Gates (1975). The Hamburg types V119-122 were loaned and are described below, possibly they are at least in part the missing Berlin 2115. Interestingly, although three of the Berlin #2117 syntypes from Enoshima are macerated with two broken in half, the other five are solid and slightly coiled, but none have been previously dissected (pers. obs.), one is slightly damaged at its hind end with soil attached, here it is sketched and figured and a tissue taken from the damaged area for DNA analysis by iBoL project].

Allolobophora (*Allolobophora*) *japonica*: Rosa, 1893: 424, 449.

Helodrilus (*Allolobophora*) *japonicus*: Michaelsen, 1900: 481; 1910: 62.

Allolobophora japonica f. *typica* Oishi, 1934: 134; Kobayashi, 1941: 151 (+ *gigantica*, *minuta*), fig. 2.

Allolobophora japonica f. *gigantica* Oishi, 1934: 134. [Tomakomai. Types?].

Allolobophora japonica f. *minuta* Oishi, 1934: 134. [Morioka, Asamushi. Types?].

Eisenia japonica: Gates, 1975: 1; Easton, 1981: 43 (syn. *gigantica*, *minuta*); Easton,

1983: 480 (syn. *gigantica*, *minuta*); Blakemore, 2003; 2005; 2007; 2008.

Note: Michaelsen (1892: 230) described "*Allolobophora japonica* Mich." and authorship and initial date are often given as "Michaelsen, 1891: 6", e.g. by Michaelsen (1900: 481); Gates (1975), Hartwich & Kilias (1989: 268) and Reynolds & Cook (1976: 120 based on Gates' work); however, Michaelsen (1900: 481) also lists "*1892: 230*" and Easton (1981: 43) has this as the authorship publication date from Michaelsen's (1892) paper (*Arch. f. Naturgesch. Jahrg. 1892. Bd. I. H.3*) which provides a full descripion. Dr Andreas Schmidt-Rhaesa informs me that the species name was just mentioned in 1891 without description, i.e. a *nomen nudum* thus the correct citation date is "1892".

Material Examined/Localities: Syntypes: Berlin "*Kat. Nr. 2177 Allolobophora japonica Michlsn. 8 Syntypen! Enosima Hilgendorf*". Notes: a stout red hair was found in the sample jar, possibly from Michaelsen's moustache!. Also Hamburg V119-122 comprising: V119 – one specimen lacking head and one complete specimen (sketched), V120 two culed and complete specimens, V121 two exceptionally large and mascerated matures (l ~145-150 mm, both sketched), V122 one macerated mature (l ~60 mm) and an anterior part. None of the Hamburg types were dissected.

Note: Michaelsen (1892) [http://biostor.org/reference/61378] specimens in Berlin collected by Dr F. Hilgendorf are labeled sequentially from 2113-2123, all except for 2115 syntypes of *Eisenia japonica* that were collected from Hokkaido by "*Fischerei-Ausstellung*" originally with their Spec. Kat. Nr. 469. Syntypes 2115, were subsequently lost from the Belin collection although they were possibly, at least in part, re-registered as syntypes of *E. japonica* as in Hamburg collection as V119-V122 (pers. obs., 2010).

Other specimens from Enoshima type-locality - several of from around Okutsunomiya shrine, col. RJB, 8.X.2002 and, significantly, on 29.III.2010 exactly 135 years after Herr Hilgendorf, and from same locality on 18.IV.2010. Also from Kyorin Daigaku, Miyashita-cho, Hachioji-shi, Tokyo (e.g. sample 20000705) ID RJB 3.VII.2001; Kamakura (col. RJB 17/22.X.2002); Yamanashi (ID RJB 8.I.2003); Okutama-yama (collected RJB, July, 2001 and 26.V.2003); YNU Wadamachi campus, Tokiwadai, Yokohama (collected by RJB 5.III.2004); Tomakomai, Hokkaido (YNU specimens 18-21.IX.2001) Id.: RJB 8.V.2003 and specimens collected from that site by RJB on 4.X.2006; 'buna' beech forest on summit of Oyama, Tanzawa Range, Kanagawa col. RJB 26.IV.2004; Ojiyamakoen (collected RJB 2.II.2007), Haguri and Kuro1-chome and Kurotsu 5-chome (17.VI.2009) all at Lake Biwa, Shiga-ken (several specimens in LBM collecton); from Hodogaya park next to Commonwealth Graves Commission

Cemetary, a single mature specimen (RJB 25.IV.2010 An415), specimen figured; and from Shuzenji, Izu-hanto, Shizuoka-ken from shrine gardens (7th May, 2010 RJB + YH but specimens not retained). Tissue for DNA was sampled from types and the recent materials that are deposited in National Museum of Nature and Science, Tokyo.

Easton (1981: 43) said it was uncertain which "*Enosima*" (sic = Enoshima) Michaelsen refered to and that Rosa (1893) noted it was near Tokyo. Almost certainly it is Enoshima, Kanagawa-ken, the site of the first Marine Biological laboratory in Asia that Edward Sylvester Morse founded soon after his arrival in 1877, significantly only two years earlier Franz Hilgendorf had visited the island (Hilgendorf left Japan in 1876 so the two men never met there) whence the current author re-collected topotypic specimens on the 135th anniversary, 29.III.2010 (specimen figured).

Diagnosis: Length 24-175 mm by 2-5.5 mm. Segmental counts up to about 125 (155 from Hokkaido). Unpigmented pink, whitish grey or dark reddish brown in preservative (bright yellow tips to both anterior and posterior, thus the immatures are quite distinctive). Body cylindrical. Prostomium mostly epilobous. First dorsal pore 4/5. Spermathecal pores in 9/10/11 in c or cd lines. Clitellum 23,24-31. Tubercula pubertatis in form of paired longitudinal ridges on 24,25-29 in mid-bc but usually with more discrete raised papillae on 27 or, typically, on 27 and 29; tumescences around ab of some of 22, 25, 26 and 32, at least. Setae closely paired (ratio ca. 10aa:1ab:5bc:1cd:30dd) and supposedly larger in the posterior. Holandric, seminal vesicles increasingly large, in 9-12. Spermathecae small in 9 and 10. Holoic.

Distribution: Considered endemic to Japan (Hokkaido to Kyushu), Korea including Jeju (from Kobayashi, 1941), possibly China (e.g., from Sansei by Ohfuchi, 1951: 62) and a report from Taiwan by Kobayashi (1939, 1940 – actually this may be my mistake for *Drawida japonica*!) although it was not much reported subsequently (Chen *et al.*, 2009: 158) there is a recent claim of a new record there (Ref.). A report is from Germany (Graff, 1954 perhaps after Wilcke's, 1940 report from garden soil) and an unconfirmed report from Slovakia on the "*Databank of Slovak Fauna*" (http://zoology.fns.uniba.sk/checklist/interface/results_page.asp?binomen=Eisenia March, 2007; cf. EDDA, 2007); also listed in a Red Data Book of the Russian Federation (Anon., 1997) from Sakhalin Island, Siberia (Perel, 1979: 78); so it may be an introduction, possibly from eastern Siberia, or have a wide natural range. Recently found from New Zealand (also present was *A. coricis* and *L. rubellus*) in swampy paddock beside steaming pool at Arataki Honey facility, Waiotapu in the Taupo

district of the Waikato region by RJB 28th November, 2011 – **new record Australasia/NZ/Southern Hemisphere** (see *E. japonica vaga* Blakemore, 2013**).**

Habitat: From woodland soils, under litter and logs; recently reported as an "*outbreak*" causing slumping of rice in irrigated paddy fields in Kanagawa, Japan (regional newspaper; October, 2005). In swampy paddock with pH 4.7 and at 24.5°C.

Behaviour: Docile to touch; has similar odour to *E. fetida* when handled or placed in water (pers. obs.) – perhaps indicative of close specific relationship.

Length: Variable, 20-175 mm (Michaelsen said that Enoshima specimens were small, up to 42 mm by 3 mm, whereas the poorly preserved Hokkaido specimens ranged to130 mm by 5½ mm; current Enoshima specimens are about 50 mm and Hokkaido specimens varied from 20-150 mm – pers. obs.). Enoshima types (2117) varied from 45-90 mm with 123-125 segments, respectively (size difference mainly due to maceration). The New Zealand specimen was 41mm long with 121 segments.

Width: 2-5½ mm.

Segments: 96-155. Body cylindrical; when disturbed the anterior retractes and just the prostomium probes looking somewhat like toothpaste initially squeezed from a tube.

Colour: Rather transparent in life so that blood vessels and ingesta show through, my specimens from Enoshima often had distinctly bright yellow coelomocytes showing through on tip of tail and, interestingly, anteriorly in both adults and immatures; whitish grey or dark reddish brown preserved; clitellum pale buff (in life and preserved).

Prostomium: Open epilobous, sometimes appearing tanylobous (as with *E. fetida*).

First dorsal pore: Small in 3/4 open from 4/5 (in syntypes and other specimens).

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired; (10:1:5:1:30:0.5).

Nephropores: Inconspicuous, alternate irregularly on each side above b and d lines.

Clitellum: Saddle-shaped, 23,24-31,32.

Male pores: Small equatorial slits confined to 15 in mid-bc lines.

Female pores: Minute, just lateral to b in 14.

Spermathecal pores: Small paired in 9/10/11 in c lines (or cd Michaelsen), not found in syntypes.

Genital markings: Tubercula pubertatis in form of paired longitudinal ridges on ½24,25-29 in mid-bc (seen in almost all syntypes and Enoshima specimens) and usually with more discrete raised papillae more ventally on 27 and 29; tumescences around ab, variably, of 16, 21, 22, 25, 26, 30 and 32 (and elsewhere?), especially in 22 and 25 but this may sometimes be unilateral. Specimens collected from Lake Biwa (by RJB 1st Feb,

2007) had some variation in genital papillae, e.g. one having paired papillae in 29 on one side and a single papillae on 27 on the other. [In the Hodogaya specimen, now identified as *E. japonica hiramoto* Blakemore, 2012, the ventral setae on 25 are most noticeably surrounded by large tumescences]. The New Zealand specimen had them most noticeably on 25 and 26.

Septa: None appear especially thickened.

Hearts: 7-11.

Gizzard: Ca**.** 17-18.

Calciferous glands : Without sacs, glands intramural, annular in 11-12 (opening behind 10/11).

Intestine origin (caeca, typhlosole): ?

Nephridia: Holoic, bladders present (sausage-shaped or digitiform).

Male organs: Testes/funnels holandric; testes iridescent in 10 and 11, seminal vesicles paired small in 9-10, larger 11, largest 12.

Ovaries: Small in 13.

Prostates: None.

Spermathecae: Two small pairs in 9 and 10 (or sometimes posterior to septa and in 10 and 11), spherical ampullae, adiverticulate (not sought in undissected syntypes).

Gut contents: Fine soil and organic material.

Economic importance: Apart from contribution to soil fertility and ecological food webs, a Korean fishing website (Ref., 2010) list these bait worms: "*eunnaksijireongyi (Allolobophora japonica gingantica)* [sic]*, soenaksijireongyi (Allolobophora japonica minuta)*" albeit they are synonymous with *E. japonica*.

Notes: Gates (1975) provides a detailed account of this species. Although some 'varieties' have been recognized, e.g. *E. japonica gigantica* Oishi, 1934: 134 and *E. japonica minuta* Oishi, 1934: 134, these were considered dubious and combined by Easton (1981: 43) and Easton (1983: 480) with which I tend to concur.

Nevertheless, *E. japonica* marker characters – that appear to be mere intergrades – used by Oishi (1934) and later by Kobayashi (1941) and by Easton (1981, tab. 2), are as follows:

Characters of *Eisenia japonica* morphs after Oishi (1934) [cf. Easton, 1981: tab. 2].

	E. j. minuta	***E. j. typica [japonica]***	***E. j. gigantica***
Length (mm)	42-55 [24-55]	60-102 [42-102]	139-175

Diameter (mm)	1.75-2.0 [1.75-2.80]	3.5-5.0 [2.5-5.0]	5.2-7.2 [3.5-7.2]
Segment number	110 [85-110]	102-140 [96-140]	125-151
Colour	Uniformly whitish grey	Ant. pink, post. whitish grey	Dark reddish brown
Shape of TP	Round	Triangular	Intermediate
	E. j. minuta	***E. j. typica***	***E. j. gigantica***

TP – tubercula pubertatis.

DNA: >JET170-11|An-417|Enoshima Japan topotype ***Eisenia japonica japonica*** |COI-5P
AACTTTATACTTTATCCTCGGAGTCTGAGCCGGGATAGTGGGTGCTGGTATAAGACTTCTCAT
TCGAATTGAATTGAGCCAGCCGGGAGCCTTCCTAGGAAGAGATCAACTATATAACACAATTG
TAACAGCCCATGCATTTGTAATAATTTTCTTCTTAGTTATACCTGTATTCATTGGGGGTTTCGG
AAACTGGCTACTTCCCTTAATACTAGGAGCCCCCGATATAGCCTTTCCACGACTTAACAATAT
AAGATTCTGACTACTGCCCCCATCCCTTATCCTACTAGTATCCTCCGCCGCAGTAGAAAAAG
GTGCAGGTACAGGATGAACGGTATATCCTCCTCTATCAAGAAATCTAGCACACGCAGGTCCT
TCAGTTGATCTAGCCATTTTCTCACTTCATTTAGCGGGAGCTTCCTCAATTCTTGGGGCTATT
AATTTTATCACTACAGTTATTAATATACGCTGAAGAGGACTACGATTAGAACGAATCCCTTTA
TTCGTATGAGCTGTAGTAATTACAGTAGTTCTTTTACTTTTATCCCTCCCAGTACTTGCAGGA
GCCATTACCATACTACTAACAGATCGAAACTTAAATACTTCATTCTTCGATCCCGCAGGTGGT
GGAGATCCAATTTTATACCAACATCTTTTC
Sept., 2017 – no genbank match LOOKS LIKE A NEW SPECIES? Dec. 2020 94% match to LC200116 "Lumbricidae sp." from Shizuoka-ken.
Note: other "*Eisenia japonica*"claims on Genbank do not match, e.g. AB542698 vs. AB542698.1 both by Minamiya that differ by 20% and from KY750699 or KX400622 etc. that are from Kurils.

>JET134-11|An-471.1|Eisenia japonica|COI-5P – Zip. *Eisenia japonica* "shiroatama" (unpublished) from Mishima.
AACTTTATACTTTATCCTCGGAGTTTGAGCCGGGATAGTAGGTGCCGGTATA
AGACTTCTCATTCGAATTGAACTGAGCCAGCCGGGAGCCTTCCTAGGAAGA
GATCAACTGTATAACACAATTGTAACAGCCCATGCATTTGTAATAATTTTCTT
CTTAGTTATACCCGTGTTTATTGGAGGTTTCGGAAACTGATTACTCCCTTTAA
TACTAGGAGCCCCCGATATGGCCTTTCCACGACTCAACAATATAAGATTCTG
ACTACTACCCCCATCCCTCATCCTACTTGTATCCTCCGCTGCAGTGGAAAAG
GGTGCAGGTACAGGATGAACGGTATACCCCCCCCTATCAAGAAATCTAGCA
CACGCAGGTCCTTCAGTAGATCTAGCAATCTTTTCACTTCATTTAGCAGGAG
CTTCCTCTATTCTTGGGGCTATCAATTTTATTACTACAGTCATCAACATGCGC
TGAAGAGGACTCCGATTAGAACGAATCCCTCTATTTGTATGAGCCGTAGTAA
TTACAGTAGTTCTATTACTTCTATCTCTTCCAGTACTTGCAGGAGCCATTACC
ATACTACTGACAGATCGAAACTTAAATACTTCATTCTTCGACCCTGCAGGTG
GTGGAGACCCAATTTTATATCAACATCTTTTC
No close match on Genbank (Dec. 2020).

Other sub-species, as noted above, are ***E. japonica hiramoto*** Blakemore, 2012 and ***Eisenia japonica vaga*** Blakemore, 2013 from Busan, Korea and apparently also New Zealand as an introduced species.

DNA: H5 *Eisenia japonica vaga* (holotype, H) from Busan (RJB)
TCTATACTTCATTCTCGGAGTTTGAGCTGGTATAGCGGGCGCAGGTATAAGAC

TTCTTATTCGAATCGAACTAAGCCAACCGGGAGCTTTTCTAGGGAGAGACCA
ACTATACAACACAATTGTGACAGCACATGCATTTGTAATAATCTTCTTTCTAGT
AATACCTGTATTTATTGGGGGTTTTGGAAATTGACTTCTACCCCTTATATTAGG
AGCTCCTGATATAGCCTTCCCACGGCTAAATAACATGAGATTTTGACTTTTAC
CCCCATCCCTTATCCTTCTAGTGTCTTCTGCCGCTGTCGAAAAGGGGGCAGG
AACGGGATGAACAGTATATCCCCCCCTATCAAGGAATCTTGCTCATGCGGGCC
CTTCAGTAGACTTAGCTATTTTTTCTCTGCACTTAGCAGGAGCTTCTTCAATTC
TAGGGGCTATCAACTTTATTACCACAGTTATTAACATACGATGAAGCGGATTA
CGTTTAGAGCGAATCCCTCTATTTGTATGAGCCGTAGTTATCACAGTAGTACT
CTTACTTCTATCCCTGCCAGTCCTTGCAGGAGCCATTACCATATTATTAACAGA
CCGAAACCTTAATACCTCATTCTTTGACCCTGCGGGGGGCGGAGACCCTATC
CTATATCAACATCTTTTT

megaBLAST result: Identities=93% Lumbricidae sp. (sic) Esik52 (AB607078); 92% Eisenia japonica from Japan (GenBank AB542698). BLASTn: H5 vs. WO20 "E. japonica" from 4th April, 2012 survey on Korea=650/655 (99%), i.e, a similar and possibly same taxon but both different from E. japonica from Japan, thus probably meriting a new name. H5 vs. JET 170-11 E. japonica japonica topotype Identities=540/652 (83%); H5 vs. JET 173-11 E. japonica hiramoto holotype Id.=363/445 (82%) i.e. dissimilar taxa.

A sympatric congener is ***Eisenia koreana*** (Zicsi, 1972), that is sometimes returned to its original genus of *Eiseniella*, which has these characters (Cs. Csuzdi pers. comm. and pers. obs. see table above): Clitellum 25-31, TP 27-28, male pores on 15 in glandular region that extendes into adjacent segments, length 42-105 mm, grey brown. See also recent discussion on this taxon by Blakemore (2012).

Cf. also ***Helodrilus hachiojii*** Blakemore, 2007 from Hachioji near Tokyo and also found sympatrically at Biwako in the Kinki region of Japan (RJB pers. obs. and as described below).

Eisenia nordenskioldi species-complex

Notes: Easton (1983: 480) lists ***Ei. nordenskioldi nordenskioldi*** (Eisen, 1879) (mistakenly spelt "*nordenskioeldi*") with synonym *E. acystis* (Michaelsen, 1903) and three subspecies, viz.: ***Ei. n. lagodechiensis*** (Michaelsen, 1910); ***E. n. manshurica***

Kobayashi, 1940 and ***Ei. n. polypapillata*** Perel, 1969, while Perel (1979: 75, 267; 1997: 69, 70) cites ***Ei. nordenskioldi pallida*** Malevics, 1956, latterly with restoration of synonym "*E. acystis* (Michaelsen, 1903)" that was overlooked by Reynolds & Cook (1976) and by Easton (1983) and was listed as ***species inquirenda*** by Blakemore (2005). [Non *Aporrectodea pallida* (Bestscher, 1900)].

Perel (1987) states: "..Eisenia nordenskioldi *in southern Kazakhstan, Siberia and the Far East is represented by the poorly pigmented form pallida. The typical form is significantly more widespread, in Siberia reaching the regions of the far north and also occurring in the eastern and south-eastern parts of the European USSR"* and Perel (1997: 22) gives location of *Eisenia nordenskioldi pallida* in "..Китая и на севере Корея." (= China and in northern Korea). These citations by Perel (1979: 75, 267; 1997: 69, 70) may be mistaken if priority yields to ***Eisenia acystis*** (Michaelsen, 1903), thus leaving ***Eisenia nordenskioldi pallida*** Malevics, 1956 as ***species inquirenda***.

Another Siberian species claimed to be similar but separate from *E. nordenskioldi* is *Eisenia atlavyntae* Perel *et al.*, 1985; see also Perel & Bulatova (2007) on polyploidy: "*Amphimictic autopolyploid races of two species of the Asian genus* Eisenia, E. nordenskioldi *and* E. atlaviniteae [sic lapsus]*, are widespread in Siberia, from its southern boundary to the arctic region, while polyploid Lumbricidae in the East-European plain, except for the Volga region, are represented mainly by parthenogenetic forms of other genera*."

Eisenia nordenskioldi nordenskioldi (Eisen, 1879)

Fig. 6.16a *Eisenia nordenskioldi* redrawn after Perel (1979: fig. 44; . 218).

Fig. 6.16b A: *Eisenia nordenskioldi mongol* sp. nov. Holotype anterio-ventral view, dorsal prostomium [plus enlargements with that of P1 boxed], posterior, plus actual setal ratios on 13; spermathecae and calciferous glands *in situ*, nephridia in 12 & 17; B: *E. n. polypapillata* after Perel' (1969: text-fig) for fair use comparison [from Blakemore (2013: fig. 2)].

Allolobophora nordenskiöldi et *nordenskiöldii* Eisen, 1879: 6, 46. [Type locality Siberia. Types in Sweden NHRS 110 and Hamburg 3519]; Michaelsen, 1900: 476.

Lumbricus (*Allolobophora*) *nordenskioeldii* : Vaillant, 1889: 146.

[Non *Allolobophora nordenskiöldii* : Michaelsen, 1891: 3 (laps.)].

Allolobophora (*Notogama*?) *nordenskjoldii* et *nordenskiöldii* : Rosa, 1893: 424, 431.

?*Eisenia fetida* (part): Kulagin, 1889: 185.

Allolobophora nordenskioldii : Garman, 1888: 73; Beddard, 1900: 414.

?*Allolobophora acystis* Michaelsen, 1903: 43. From Turkestan. Types in St Petersburg Museum.

[?*Eisenia nordenskioldi pallida* Malevics, 1956 cited in Perel, 1997: 70. ***Species inquirendum***].

Eisenia nordenskiöldi : Michaelsen, 1901: 72; Zicsi, 1972: 131.

Eisenia nordenskioldi : Perel, 1979: 218, fig. 44 (syn. *Allolobophora acystis*); 1987.

Eisenia nordenskioldi nordenskioldi : Perel, 1997: 69, 70 (misdated "Eisen, 1873" and statement that the previous "*E acystis* Michaelsen, 1903" synonym was erroneous); Blakemore, 2004; 2005; 2013.

Taxonomic Notes (after Blakemore, 2005): ***Ei. nordenskioldi nordenskioldi*** (Eisen, 1879: 6) (Emend.) was originally spelt "*nordenskiöldi*" named, according to Michaelsen (1900: 479), after the famous Finnish explorer and "Vega" expedition leader, Baron Nils Adolf Eric Nordenskiöld (1832-1901), and thus, because the "ö" here is a special letter of the Finnish or Swedish alphabet and not the German umlaut sign, under the code ICZN (1999: Art: 32.5.2.1) it is corrected here as in Michaelsen (1900) with only the diacritic removed. An invalid alternate original spelling is "*nordenskiöldii*" Eisen (1879: 46) and the name is sometimes misspelt "nordenskioldii", "nordenskioeldii", "nordenskjoldii", "nordenskiöldii", "nordenskjöldi" e.g. by Reynolds & Cook (1976: 145), or "nordenskioeldi" e.g. by Easton (1983: 480) or rather uniquely, but repeatedly, as "nördenskiöldii" by Qiu & Bouché (1998: 198).

The nominal species' diagnosis follows Michaelsen (1900: 476 from his inspection of original specimens), and is from Kobayashi (1940; 1941), Zicsi (1972) and Perel (1979; 1997) for ***Eisenia nordenskioldi nordenskioldi*** (Eisen, 1874) [?syns. *acystis* Michaelsen, 1902; *pallida* Malevics, 1956 (cf. Perel, 1997) - neither taxon listed in Reynolds & Cook (1976)].

Moreover, Reynolds & Cook (1976: 85) list a taxon: '*Eisenia nordenskjöldi* var. *caneasia* Mich. 1907: 82' (sic) with types in Hamburg 6959; this is possibly a mistake for ***Ei. nordenskioldi caucasica*** Michaelsen, 1903: 38 (= *Ei. fetida*) that they omit citing.

Diagnosis: Length 25-150 mm. Width 2-8 mm. Segments 80-176. Pigment exuberant puce alive or absent preserved (Zicsi, 1972) or possibly pale when alive (e.g. Perel, 1979: 635), absent dorso-laterally on 9-11 (the *pallida* morph is paler whereas the

pigment of the the *acystis* morph, if any, is brown). Prostomium epilobous. Setae closely paired (aa>bc, dd<0.5 U). Setae ab on 16, 22-34 and cd on 9-11 on papillae. First dorsal pore 4/5. Spermathecal pores in 9/10/11 mid-dorsally. Clitellum 26,27-33,½33. Tubercula pubertatis 29-31(or 28-30 by Garman (1888: 73). Male pores tumescences confined to 15. Calciferous glands in 11 and 12. Seminal vesicles in 9-12. Spermathecae paired in 9 and 10.

Distribution: *E. nordenskioldi* has been reported from the west in Russia (and from the polar Wrangel Island reserve) and east in northern Korea and Siberia to Chukotka and Sakhalin Island (e.g. Perel, 1979: 78), possibly as far south as Crimea and possibly as far west as Sweden (Michalsen, 1900: 476), a range overlapped by *E. fetida*, although the extent of naturally acquired distributions are difficult to determine. Garman (1888: 73) says "*Obtained by Eisen in Siberia; credited to North America by* Vejdovsky." Also reported from Hawaii (e.g. Beddard, 1900) but, like the Azores report, this is probably a mistake. Perel (1997: 22) gives location of dubious *Ei. n. pallida* morph in China and North Korea.

Blakemore (2012, unpublished) found unidentified *Eisenia* sp. on Jeju that has 96% match on Genbank Sept. 2017 with "Eisenia nordenskioldi" from Korea KM593697 & KM593698 from 2015. >WO17 DNA data from Blakemore (2012):
ACTCTATATTTTATTCTAGGAGTATGAGCCGGCATAGTAGGTGCTGGAATAA
GTCTTCTTATTCGAATTGAGCTAAGTCAACCTGGGGCTTTTCTAGGTAGAGA
TCAACTCTACAACACGATTGTTACAGCTCATGCATTTGTGATAATCTTCTTC
TTAGTAATACCCGTATTTATTGGAGGATTTGGAAACTGACTCTTACCTCTAA
TATTAGGAGCACCTGATATAGCCTTCCCCCGTCTAAATAATATAAGATTCTG
ATTACTACCTCCTTCCCTCATTCTTCTTGTATCTTCTGCAGCAGTAGAAAAA
GGGGCCGGAACAGGCTGAACCGTATATCCCCCTCTATCGAGGAACCTTGCA
CATGCCGGCCCATCCGTAGATTTAGCTATCTTCTCCCTTCATCTAGCAGGAG
CTTCTTCTATTCTCGGGGCCATCAATTTCATTACTACAGTTATTAATATGCGG
TGAACAGGAATACGTCTAGAACGAATCCCTTTATTTGTTTGAGCTGTAATCA
TTACAGTAGTTCTTCTTCTTCTTTCACTTCCAGTGCTTGCTGGAGCAATTACA
ATGCTCCTAACAGATCGAAACCTCAATACTTCATTCTTTGATCCTGCGGGAG
GAGGAGACCCTATCCTTTATCAACATCTATTC

Probably the Jeju specimen is one of the dozen sub-species as checklisted below.

Remarks: The characteristics and distributions of *E. nordenskioldi* are both within the known ranges for the *Eisenia fetida* species-complex, the only superficial and dubious

difference is perhaps the tubercula pubertatis starting a half segment futher posteriorly than usually recorded in *E. fetida* (i.e., in 29 rather than ½28). However I have also observed specimens of *E. fetida* from Japan that have tubercula pubertatis on 29-32 (now thought as likely *D. veneta*). (Also cf. *Aporrectodea rosea*, *Eisenia japonica*).

Sexual forms of the *Eisenia nordenskioldi* complex are reported to have even ploidy levels (orthoploids) ranging from (2n-8n) while the only recorded parthenogen is a deep-burrowing septaploid (7n) (Viktorov, 1997). *E. nordenskioldi pallida* may be di- or tetraploid, and ecological differences of polyploid vs. diploid morphs permits wide distribution of each form: more wide the higher the ploidy level [Perel (1987); Lundmark & Saura (2007 *Hereditas* online) and see Perel & Bulatova (2008)].

Freeze tolerance down to -30°C has been reported for *E. nordenskioldi* (morph?) by Berman & Leirikh (1985) and Holmstrup & Petersen (1997), the worm will immediately produce a high concentration of glucose once ice is formed at sub-zero temperatures. Berman et al. (2002) also report its adaptation to arid conditions.

Strigonova (1984) earlier reported:-

"*Feeding of* E. nordenskioldi *was investigated in 1978 and 1982 in tundra areas in the Dikson region. Plant detritus predominated in the intestinal contents and among plants above ground parts and roots of dryads and grasses predominated. In laboratory experiments mosses were not eaten but Nostoc was consumed rapidly. Feeding activity was low at 6°C. Partial dehydration appeared to assist in survival at low temperatures. At low temperatures respiration rate and rate of digestion were low.*"

Annotated checklist of *Eisenia nordenskioldi* species-complex (chronological) updated from Blakemore (2013).

1. *E. nordenskioldi nordenskioldi* (Eisen, 1879: 6). [Emend. corr. from *nordenskiöldi* e.g. by Blakemore (2008a p. 39); Perel (1979 p. 218) originally included *Allolobophora acystis* in synonymy; but she later stated (Perel 1997 pp. 69-71) that the previous "*E. acystis* Michaelsen, 1903" synonym was erroneous. Miscited as "*nordenskioeldi*" by Blakemore (2004 p. 98) after Easton (1983 p. 480) from original spelling of "*nordenskiöldi*" and as per Michaelsen (1900 p. 476), since it is named after the famous explorer – Baron Nils Adolf Eric Nordenskiöld (1832-1901) – the 'ö' is Finnish and not a German umlaut so was corrected under ICZN (1999 Art: 32.5.2.1) with just the diacritic removed.

Alternate original spelling "*nordenskiöldii*" Eisen (1879: 46). Name sometimes misspelt "*nordenskioeldii*", "*nordenskjoldii*", "*nordenscioldi*", "*nordenskiöldii*", or "*nordenskjöldi*" e.g. by Reynolds and Cook (1976 p. 145); misquoted as "Eisen, 1873" in Perel' (1997 p. 69)]. Furthermore, Reynolds and Cook (1976 p. 85) cite a taxon: "*Eisenia nordenskjöldi* var. *caneasia* Mich., 1907: 82" (sic), probably a mistake for *Eisenia nordenskioldi caucasica* that they omit].

2. *E. nordenskioldi caucasica* Michaelsen, 1903: 38 ***species inquirendum*** [non *Dendrobaena caucasica* Kulagin, 1889 (= *D. veneta*)]. [Often misdated "1902" as with *acystis*. From Transcaucases, to 2,500 m altitude (Michaelsen, 1903 p. 39) found also in association with *E. fetida*; its clitellum is 24,25-33 and TP 27,28-31 or 28-½32 . Although Michaelsen has types in St. Petersberg they are listed in Hamburg (6959) by Reynolds & Cook (1976 p. 85) for their "*Ei. nordenskjöldi caneasia* Mich., 1907: 82" (sic, lapsus pro *caucasica*) in a 1907 Georgian publication that seems not to exist. Easton (1983 p. 480) at least placed *caucasica* in synonymy of *E. fetida*, although this placement requires re-evaluation with the benefit of recent taxonomic advances (e.g., DNA and IBM)].

[***Ei. nordenskioldi caucasica*** Michaelsen, 1903 is now in synonymy of *Eisenia fetida*].

3. *E. nordenskioldi acystis* (Michaelsen, 1903: 43) ***species inquirendum***. [Originally *Helodrilus acystis*; ?non "*Haplotaxis acystis* Michaelsen, 1903: 43" (lapsus?) – this taxon, often repeated on species databases, has the same publication data and is likely a mistake]. [A parthenogenetic sub-species of some part of the species-complex lacking spermathecae (and spermatophores?); it was unpigmented, described with clitellum in 26-33 and TP in 29-½31; seminal vesicles in 9-12; *cf. E. n. pallida*. From Turkestan with types in St. Petersburg Museum. Dr T. Perel (pers. comm. via A. Leirikh 27th Feb. 2012) now considers it a separate taxon from *E. nordenskioldi*. Note: Its publication date is confirmed as 1903 since the journal states "*Augegeben am 27. Mai 1903*" rather than "1902" as scheduled].

4. *E. nordenskioldi lagodechiensis* (Michaelsen, 1910: 18) ***species incertae sedis***. [From Georgia, the types probably in St Petersburg. Its species distribution is the eastern Caucasian region (Ref.). Omitted from Reynolds & Cook (1976). Originally in *Helodrilus*; returned to separate species level by Kvavadze (1993) because its developed male pores are apparently distinctive (cf. Kobayashi's, 1940 taxa)].

5. *E. nordenskioldi manshurica* Kobayashi, 1940: 284 ***species inquirendum*.** [Sometimes included as a synonym of nominal sub-species, its characters probably justify its separation: Dark pigment. Length 111-144 mm, segments 154-175), clitellum in 26,27-34 and TP 29-32. Type-locality is likely Anshan, where two clitellate specimens were found (August, 1938) along with two aclitellate specimens; other semi-clitellates from Chinhsien and Mutanchiang in Dongbei province (ex Manchuria) but all syntypes are now lost following Pacific and Korean wars. It is also omitted from Reynolds & Cook (1976)].
6. *Allolobophora hataii* Kobayashi, 1940: 288 ***incertae sedis*** (usually put in *A. rosea*).
7. *Allolobophora harbinensis* Kobayashi, 1940: 290 ***incertae sedis.*** [Usually put in *A. rosea*. Possibly *Al. harbinensis* is a sexual morph (and therefore an invalid synonym) of *Al. hataii*. Alternatively, it may represent the amphimixic form of a separate taxon or, equally possible, they are subspecies of either of *E. fetida* (most likely) or *E. nordenskioldi* but with spermathecal pores more lateral in *cd* lines].
8. *Allolobophora dairenensis* Kobayashi, 1940: 291 (syn. *Al. jeholensis* Kobayashi, 1940: 293 that differs inconsequentially) ***incertae sedis***. [Usually put in *A. rosea*. Nothing of substance separates Kobayashi's *Al. jeholensis* from his page prior *Al. dairenensis* so it, at least, should be subsumed. Both yet have the flared clitella in 29-31 characteristic of *Ap. rosea* and neither are superficially distinguishable from *Aporrectodea rosea* itself defined with clitellum in 25,26-31,32 and TP 29-½31,31 or thereabouts, plus several combinations of setal tumescences. Internally *Ap. rosea* has spermathecae absent or in 9/10/11 dorsally; calciferous glands in 10; U-shaped nephridial bladders and it has a compound typhlosole – see Blakemore (2010, 2012). Thus possibly some or all of Kobayashi's taxa, as well as athecal *Al. prashadi*, may either be Manchurian candidates for *Ap. rosea*, or for parts of the *E. fetida* and *E. nordenskioldi* spp.-complexes].
9. *E. nordenskioldi pallida* (Malevic, 1956: 439) ***species inquirendum*** (non *Allolobophora pallida* Bretscher, 1900: 41). [Cited in Perel' (1969 p. 62, 1979 pp. 75, 267) and Vsevolodova-Perel (1997 pp. 69-71) as *E. nordenskiöldi pallida* Malevic, 1956 latterly with restoration of synonym *E. acystis* (Michaelsen, 1903) - this possibly a mistake as the priority would yield to *E. acystis* with *acystis* itself possibly remaining a synonym of the nominal subspecies. Both taxa overlooked by Reynolds & Cook (1976) and by Easton (1983). The original reference (listed as "Ucs. Zapisk. M. Gor. Ped. Inst. 61:

439-448" on www.earthworm.uw.hu) was inaccessible at time of current submission. Perel (1997: 22) locates this dubious morph in China and North Korea].

10. *E. nordenskioldi polypapillata* Perel, 1969: 61 ***species inquirendum***. [Its papillae and position of spemathecae, as originally described, are perhaps definitive (Tab. 1). Collected in May, 1967 from "*Dsungar-Ala-Tau, Bezirk Sarkand, Försterei Topolevskoje*" (a forestry station in Sarkand district of the Dzungarian Alatau mountain range at Almaty Province of south-eastern Kazakhstan); found in Apple and Fir forest at 1,200-1,500 m altitude. Holotype and Paratype from ten poorly-preserved specimens in Zoological Museum of Moscow University, No. W-10. Dr Perel now suspects it is synonymous (pers. comm. via Anna Leirikh Dec. 2012) "*She also now suppose that* E. n. polypapillata *in fact is* E. n. pallida*, and some authors considers* E. n. pallida *as separate species*"; however the relationship of both to prior *E. n. acystis* remains unclear as noted above].
11. *E. nordenskioldi mongol* Blakemore, 2013 subsp. nov. with its DNA data provided.
12. *E. nordenskioldi onon* Blakemore, 2013 subsp. nov. with its DNA data provided.

Genus ***Eiseniella*** Michaelsen, 1900

Eiseniella Michaelsen, 1900: 471 [nom. nov. pro *Allurus* Eisen, 1874, vol. 30: 45, 54 non *Allurus* Foerster, 1862 (Hymenoptera)] [non *Eiseniella* Ashmead, 1906 (Hym.)].

[Syn. *Tetragonurus* Eisen, 1874 vol. 31: 47 (type-species: *T. pupus* Eisen, 1874 = *E. tetraedra pupa*) non *Tetragonurus* Risso, 1810 (Pisces)].

Type-species: *Enterion tetraedrum* Savigny, 1826.

Diagnosis: Male pores often asymmetric and displaced from 15 (usually to 13). Calciferous sacs digitiform, opening directly into the oesophagus in 10 ventrally just in front of septum 10/11. Calciferous lamellae continued along the lateral walls of the sacs. Nephridial vesicles shortly sausage-shaped (or J-shaped in *tetraedra*). Nephropores inconspicuous, alternate irregularly on each side of the body above b and d lines. Hearts in 7-11. Setae not closely paired behind the clitellum. Prostomium prolobous, epilobous or zygolobous. Amphibious or limnic. Basic chromosome number is n=17 (Gerard, 1964: 42). The cross-section of longitudinal muscle layer is of the pinnate type.

Taxonomic Notes: Michaelsen (1935a) thought this genus was allied to *Allolobophora*, but Gates (1972: 112) believed that the genus was closest to *Lumbricus*.

Distribution: Palaearctic. Approximately six species plus 3-4 subspecies of the type that is most commonly transported. *Ei neapolitana*, formerly included as subspecies *Ei. tetraedra neapolitana* but now separated, also appears widely distributed.

Key to widely distributed species:

Male pore usually 13, clitellum 22,23-26,27; TP 22,23-25,26 … *Ei. tetraedra* sub-spp.

Male pore 13 or 15, clitellum 20,21-24,25; TP 21,22-24 …… *Ei. neapolitana*

Eiseniella neapolitana (Örley, 1885)

Allurus neapolitanus Örley, 1885: 12. [From Naples. Types in Berlin: 5012].

Allolobophora ninii Rosa: 1886: 680. [Types in Turin: 9].

Eisenialla tetraedra neapolitana + *ninnii*: Michaelsen, 1900: 473.

Helodrilus tetraedrus forma *neapolitana* + *ninnii* : Smith, 1917: 162.

Allolobophora (*Eiseniella*) *tetraedra var. sewelli* Stephenson, 1924: 363. [Types in Calcutta: 1142].

Reynoldsia andaluciana Qiu & Bouché, 1998: 103. [Types in France]. [Preocc. genus name, non *Reynoldsia* Malloch, 1934: 230 (Diptera), replaced by *Norealidys* Blakemore, 2008]. [Csuzdi pers. comm. (May, 2008) says *Norealidys andaluciana* is a junior synonym of *neapolitana*. **Syn. nov.**].

Eiseniella neapolitana: Michaelsen, 1900; Omodeo & Rota, 2004: 238; Csuzdi & Pavlicek, 2005a: 91; Csuzdi, 2008 (pers. comm.) (syns. ?*ninnii* Rosa, 1886; *sewelli* Stephenson, 1924; *andaluciana* Qui & Bouché, 1998).

Notes: Previously regarded as a subspecies of *Ei. tetraedra* but redefined as a valid taxon at species rank e.g. by Omodeo & Rota (2004: 238) who, nevertheless, avoided inspection of types and overlooked synonyms; and by Csuzdi & Pavlicek (2005a: 91).

Diagnosis: Male pores on 15; clitellum 20,21-24,25; TP 21,22-24.

Description (after Ref. and Smith, 1917): *External* – Body length 20–80 mm, diameter 1.5–2.5 mm. Segments 150. Color brown or yellowish -brown. Head epilobous, first dorsal pore in 4/5. Setae closely paired. Clitellum extends on segments 20,21–24,25. Tubercles on 21,22–24. Male pores great, open on 13 (or 15?). Nephridial pores alternate irregularly between *b* and above *d*. The body has a

characteristic quadrangular shape behind the clitellum, with setae on the edges. *Internal* – Septa 7/8–11/12 thickened. Crop in 15–16. Gizzard small, confined into one segment in 17. Two pairs of testes free in 10,11, and four pairs of seminal vesicles in 9–12. Receptaculae seminalis two pairs in 9/10–10/11 open above setal line *cd*. Calciferous glands with diverticula in 10. Excretory system holoic with sac –shaped nephridial bladders. The cross section of longitudinal muscle layer are of pinnate type.

Distribution [after Michaelsen (1900); Csuzdi & Pavlicek (2005a: 92); Csuzdi, Pavlicek & Misirlioglu (2008: 348) – report from Turkey]: From Mediterranean, Middle East and California. Michaelsen had *neapolitana* from Italy (Naples) and California (Redding); and including *ninii* [according to Michaelsen from: "*Syrien und Palastina (Homs, Damaskus, Ain-Musa, Ain-Dschedur), Italiea (Treviso, Pavia), Californien (Redding)]*" and Stephenson's *Ei. t. sewelli* from Palestine (today Israel) that was possibly described with "*Indian and Palastinian earthworms*" by Stephenson (1922), rather than an "Indian species" as reported by Stephenson (1924), either way, it seems it is not from India. Also from Andalucia, Spain (see following note).

Notes: Cs. Csuzdi (pers. comm. 17th Sept., 2008 and http://earthworm.uw.hu/) says: "Norealidys andaluciana [from Spain] *is nothing else just a synonym of* E. neapolitana. *It is a circummediterranean species with high ecological and morphological plasticity. Its clitellar and tubercular data fit well in* neapolitana" .

Eiseniella tetraedra species-group

Eiseniella tetraedra tetraedra (Savigny, 1826)

Fig. 6.17. *Eiseniella tetraedra* Tasmanian specimen ventral view with (dorsal) spermathecae, dorsal view of prostomium.

Fig. 6.17a. *Eiseniella tetraedra* Taiwan specimens, both samples from Chichiwan Stream, Wuling Farm, Shei-Pa National Park, collected 2004 – lhs thin and white : rhs stubby and dark – the apparent difference in colouration and body form between specimens in both sample tubes is due to different preservation methods, all specimens are actually identical. {Photo Yuko Hiramoto}.

Fig. 6.17b. *E. tetraedra* known ditribution map.

Enterion tetraedrum Savigny, 1826: 184. [Type locality Paris. Types in Paris Museum].

Lumbricus amphisbaena Dugès, 1828: 293. [Types missing].

Lumbricus tetraedrus : Dugès, 1837: 8, 17, 23.

Lumbricus agilis Hoffmeister, 1843: 191; 1845: 36. [Types missing].

Lumbricus tetraedrus luteus Eisen, 1871: 966. [Types?].

Tetragonurus pupa Eisen, 1874: 47; Smith, 1917: 163. [Types missing].

Allurus tetraedrus : Eisen, 1874: 54; 1877: 47; Ribaucourt, 1896: 69.

Allurus hercynius Michaelsen, 1890: 7. [Types Hamburg: 167].

Allurus dubius Michaelsen, 1890: 7. [Types missing].

Allurus tetraedrus luteus : Friend, 1892: 90. ["Types" are given as BMNH: 1923:12:31:376 by Reynolds & Cook, 1976: 130]. [Cited by Reynolds & Cook, 1976: 130 as if a valid separate taxon though almost certainly a reference to Eisen's *luteus* which they overlook].

Allurus tetragonurus Friend, 1892: 194, 272. [Types BMNH: 1923:12:31:122].

Allurus macrurus Friend, 1893: 402, 461. . [Types BMNH: 1923:12:31:350].

Allurus amphibaena : Friend, 1893: 462 [cited by Reynolds & Cook, 1976: 69 as valid separate taxon though almost certainly a reference to Duges' *amphisbaena*].

Allurus tetraedrus bernensis + *novis* + *infitesimalis* Ribaucourt, 1896: 73, 74, 74. [Types?].

Eiseniella tetraedra typica + *hercynia* + *bernensis* + *pupa* + *tetragonura* + *macrura* : Michaelsen, 1900: 471-474.

Eiseniella tetraedra hammoniensis Michaelsen, 1909: 63. [Types?].

Allurus mollis Friend, 1911: 63. [Types missing].

Helodrilus (Eiseniella) tetraedrus forma *typica* + *hercynia* : Smith, 1917: 161.

Eiseniella intermedius (sic) Jackson, 1931: 123. [From water margins of Monger's lake, Western Australia. Types?]. [Non Cernosvitov, 1934 = ***Ei. tetraedra cerni*** Blakemore, 2004 (replacement name)].

Eisenia tetraedra (Sav.) forma *typica*: Michaelsen, 1935a: 40 (syn. *intermedia*).

Eiseniella tetraedra popi Zicsi, 1960: 435. [Types Budapest: 6].

Eiseniella tetraedra: Gerard, 1964: 42; Stöp-Bowitz, 1969: 182; Gates 1972: 108-113; Reynolds, 1977: 84, fig. 26; Sims & Gerard, 1985: 90, fig. 29, 30; Blakemore, 1999: 183; Blakemore, 2000: 33, fig. 22; Csuzdi & Zicsi, 2003: 153 (syn. *quadrangularis*, *amphisbaena, agilis*, *tetraedrus luteus, tetraedrus obscurus, pupa, dubius, hercynius, tetragonurus, flavus, macrurus, tetraedrus novis, tetraedrus bernensis, tetraedrus infinitesimalis, tetraedra hammoniensis, mollis, tetraedra intermedia* Jackson, 1931, *tetraedra intermedia* Cernosvitov, 1934; *tetraedra quadripora, tetraedra popi, tetraedra phorogenesa* Qiu & Bouché, 1998: 104, *tetraedra proporandra* Qiu & Bouché, 1998: 105).

Eiseniella tetraedra tetraedra: Easton, 1983: 481 (syn. *quadrangularis* Risso, 1826; *amphisbaenus* Dugès, 1828; *agilis* Hoffmeister, 1843; *tetraedrus luteus* Eisen, 1871; *dubius* Michaelsen, 1890; *tetragonurus* Friend, 1892; *macrurus* Friend, 1893; *flavus* Friend, 1893; *tetraedrus bernensis* Ribaucourt ,1896; *tetraedrus novis* Ribaucourt, 1896; *tetraedrus infinitesimalis* Ribaucourt, 1896; *tetraedra hammoniensis* Michaelsen, 1900; *mollis* Friend, 1911; *intermedia* Jackson, 1931; *tetraedra popi* Zicsi, 1960); Blakemore, 2007 (syns. as above and Notes below).

Eiseniella tetraedra phorogenesa Qiu & Bouché, 1998: 104. [Note: possibly a synonym of *hercynius* (= E. *tetraedra pupa*) - placed in synonymy of *Ei. tetraedra* by Csuzdi & Zicsi (2003: 153)]. [Types, with lowest priority, in France].

Eisenialla tetraedra proporandra Qiu & Bouché, 1998: 105 - placed in synonymy of *Ei. tetraedra* by Csuzdi & Zicsi (2003: 153). [Types, with lowest priority, in France].

Taxonomic Notes: Easton (1983) lists these subspecies: ***Ei. tetraedra intermedia*** Cernosvitov, 1934 [non Jackson, 1931 – Cernosvitov's junior homonym is now ***Ei. tetraedra cerni*** Blakemore, 2004 (replacement name)]; ***Ei. t. neapolitana*** (Örley, 1885) [syns. ?*ninnii* Rosa, 1886; *tetraedra sewelli* Stephenson, 1924 and recently elevated to species level by Csuzdi & Pavlicek, 2005 – see separate entry]; and ***Ei. t. pupa*** (Eisen, 1874) [syns. *hercynius* Michaelsen, 1890: 7; *tetraedra quadripora* Cernosvitov, 1942: 220]. According to Csuzdi & Zicsi (2003: 153-157) either *Ei. t. pupa* (or rather its synonym *Ei. t. hercynia*) and *Ei. t. cerni* are in synonymy of *Ei. tetraedra*, or they are are separate subspecies, or merely morphs with male pores in 15, 14 and 13, respectively. However, as the only differences of several *tetraedra* taxa are the locations of the male pores, they are likely to all be 'varieties' rather than subspecies. Variations are usually thus:

Ei. t. cerni Blakemore, 2004. [Types: Prague: III-I-28 and BMNH: 1949:3:1:648]. [Formerly *Ei. t. intermedia* Cernosvitov, 1934 (non Jackson, 1931).

Diagnosis: Male pores on 14; clitellum 22,23-26,27; tubercula pubertatis 23,24-26; seminal vesicles 9-12; gizzard 17.

Distribution: From Crete, the former Yugoslavia and Norway (Stöp-Bowitz, 1969: 184) also from Chile (Brown & Fragoso, 2007).

Ei. t. tetraedra (Savigny, 1826):- male pores on 13 (or 15). [Synonymy above and described in more detail with Distribution below].

Ei. t. pupa (Eisen, 1874):- From Niagra, USA. [Types missing].

Diagnosis: Male pores on 12 or 15 as with morphs of some other sub-species.

Distribution: From Niagra; Germany; Portugal; USA (California and Illinois); Brazil; England (Tring, Hertfordshire; Ashby-de-la-Zouche, Leicestershire); and Fifeshire, Scotland].

Another dubious subspecies is:

Ei. t. peleensis Tzelepe, 1943:1. [Types missing]. [Elevated to species level in Easton (1983) but not in Csuzdi (2003) (non *Octodrilus peleensis* Michalis, 1995)].

Diagnosis of *Ei. tetraedra* spp-complex: Length 20-80 mm. Dark brownish green often with reddish brown or golden yellow hues. Body cylindrical in anterior, quadrangular after clitellum. Prostomium epilobous. First dorsal pore 4/5. Spermathecal pores in 9/10/11 above d lines. Clitellum 22,23-26,27. Tubercula pubertatis in form of narrow longitudinal bands on 22,23-25,26 usually ½23-½26 along ventral border of clitellum; tumescences often around ab on some of 8-15, also in clitellar region in 18-25. Setae closely paired. Male pores usually on 13, infrequently on 9-11, 12, 14, or 15; often asymmetrical.

Distribution (excluding for *neapolitana*)**:** Western Palaearctic (possibly endemic in north Balkans – Gerard), Scandinavia to Pri-urals; Adriatic and Mediterranean also the Levant many locations, e.g. a spring at Mt Meon, Galilee, Israel (Csuzdi & Pavlicek, 2005); Algeria (e.g. claim from Algeria by Baha, 1997), rocco; Libya; Syria; Iran; Afghanistan; Turkestan; Tajikistan, etc.; now introduced into mainly temperate regions including northern Nearctic (e.g. Canada, Pennsylvania, California, Ohio, Michigan, Indiana, Illinois, Colorado, Washington (Puget Sound) and Minnesota), southern South America [e.g. Rio Grande do Sul, Brazil and Navarino Island south of Tierra del Fuego, Chile (Anderson, 2003) where in 1830 Captain Fitzroy commanding the *Beagle*, landed and took 4 young Fuegian hostages in retribution for a stolen boat, returning them on the *Beagle*'s 2nd trip with Charles Darwin in January, 1833, and revisiting again in March, 1834], remote Juan Fernández Islands (now renamed by the Chilean government as "*Robinson Crusoe Islands*" to commemorate the story of the same name based on Alexander Selkirk's sojourn there); Azores; Canary Islands; Cape Verde; St Helena; Tristan de Cunha (Gates, 1972: 109); Mexico; Colombia at 3,000m (Feijoo *et al*., 2004); Peru, Bolivia, Argentina, Mexico, Colombia, Venezuela, Ecquador (Brown & Fragoso, 2007); South Africa (e.g. Michaesen, 1913); India; New Zealand and Australia: infrequently reported from south-western WA [*Eiseniella intermedius* (*sic*) Jackson, 1931 synonomised by Michaelsen, 1935a: 40; Easton, 1983],

NSW (Michaelsen, 1907a; Barley & Kleinig, 1964), Brownhill Creek in SA (J. Buckerfield, pers. com.), Macquarie Island and New Zealand, (Lee, 1959: 364), but not yet recorded from Qld. Current specimens were found in Vict. and Tasmania, and Taiwan and Toyama-ken central Japan (all new records – see Blakemore in Blakemore *et al.*, 2007a). Not re-located on Macquarie Island during author's re-survey in 1997/8.

Locality: Adelaide, SA; and Churchill, Vict. (collector G. Hirth), and Lake Pedder, Tas. (Blakemore, 2000a) – new records for Australia. Also from running water of Chichawan Stream on Wuling Farm, Shei-Pa National Park, NE Taiwan (specimens c/o J.-H. Chen of NTU collected 13th February, 2004); and a specimen (collected December, 2005 and delivered to YNU for identification by RJB) from a river in Toyama-ken in central Honshu, Japan; plus new records from Shirotaki Park, Mishima, Shizuoka-ken. Both new country records for Asia (Blakemore, 2004; Blakemore *et al.*, 2007a).

Habitat: Wells, springs, underground waters, mountain torrents, banks of rills, ditches, brooks, streams, canals, rivers, pools, ponds, swamps, marshes and lakes (60 cm deep in Peruvian mountain lakes); under stones or moss and in moist or alkaline soils; caves; peaty to organic soils also in sewage, sand and gravels (pH 4.6-8.5); in "nearly saline" meadows (Virginia), alkaline chernozems, forests, steppes, taiga (Russia); the dominant species in marshes of the Hebrides.

Behaviour: "*small, quick and lively*" (Eisen, 1871: 968). Aquatic or limnic. Food, at the Endgebieten der Schlei, was found to be diatoms (Gates, 1972: 110). Spermatophores produced but reproduction probably mostly parthenogenetic.

Length: 20-80 mm.

Width: 1.5-4.0 mm.

Segments: 60-160, usually 70-90. Body rather short and stumpy; cylindrical anteriorly, quadrangular after clitellum.

Colour: Dark brownish green often with reddish brown or golden yellow hues, darker mid-dorsal line; clitellum buff.

Prostomium: Usually open epilobous, sometimes prolobous or zygolobous (Gerard).

First dorsal pore: (3/4)4/5(5/6 or further back).

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired; (3:1:3:1:6:? in anterior or after the clitellum = 4.8:1:4.8:1:10); ventral setae of segment 10 often modified as genital setae.

Nephropores: Inconspicuous, behind 15 alternate irregularly on above b and d lines.

Clitellum: Saddle-shaped to almost annular usually reported in 22,23-26,27.

Male pores: Small equatorial slits confined to 13 in mid-bc lines [usually but also rarely reported on 11 or 15 or in any of 9-15, and sometimes doubled, (Gates)].

Female pores: Minute, just lateral to b in 14; median to a in some current specimens.

Spermathecal pores: Small paired in 9/10/11 above d lines but not as far as mid-dorsum, or absent or aberrant.

Genital markings: Tubercula pubertatis in form of narrow longitudinal bands on 22,23-25,26 usually ½23-½26 along ventral border of clitellum; tumescences often around ab on some of 8-12, 14-15, also in clitellar region in 18-25

Septa: Delicate although 7/8-11/12 are slightly thicker.

Hearts: 7-11; 7-12 in some of current specimens although the last pair small.

Gizzard: Weak in 17 (or17-½18); preceeded by large crop in 15-16.

Calciferous glands: Sacs digitiform in 10 opening directly into the oesophagus ventrally just in front of septum 10/11; lamellae continued along lateral walls of sacs.

Intestine origin (caeca, typhlosole): 17 (sometimes just impinging into 18); typhlosole lamellar beginning in region of 20-22.

Nephridia: Holoic, bladders shortly sausage-shaped [or J-shaped, Gates, 1972:112)]; elongate in current specimens.

Male organs: Testes/funnels holandric; seminal vesicles paired small in (some or all) of 9-12.

Ovaries: In 13; small ovisacs in 14.

Prostates: None.

Spermathecae: Two small pairs in 10 and 11, spherical ampullae, adiverticulate non-iridescent in current specimens; sometimes absent or aberrant.

Gut contents: Organic material.

Notes: Rampant parthenogenetic polymorphism characterizes *Ei. tetraedra*; spermatophores sometimes produced, and seen in current Tasmanian specimens attached in region of segment 20 but not iridescent internally i.e., no spermatozoa.

Chromosome numbers reported are ?4n=72 and ?3n=50 and 54 (Gerard, 1964).

Regeneration of lost segments is rapid: Hoffmeister (1845: 37) said 20 (tail) segments were regrown in 7 days.

Especially the small "*hercynia*" (= *pupa*) morph with male pores on 15 instead of 13, is easily confused superficially with *Bimastos parvus* but location of female pores ventral to setae *a* rather than lateral to setae *b* may be a distinguishing characteristic.

Genus ***Eisenoides*** Gates, 1969

Eisenoides Gates, 1969: 307.

Type-species: *Allolobophora lönnbergi* Michaelsen, 1894 [corr. *Eisenoides lonnbergi* (Michaelsen, 1894: 179)]. **Emend.** Blakemore (2005, 2007) [originally *lönnbergi*, sometimes misspelt "*loennbergi*" but, as the name is of Scandinavian rather than German origin (named for collector Dr Einar Lönnberg), under ICZN (1999: Art: 32.5.2.1) it is corrected to 'o' with only the diacritic removed rather than made 'oe'].

Diagnosis: Epilobous. Lumbricine with closely paired setae at corners of squarish body. Spermathecal pores paired mid-dorsally. Clitellum 23,24,25-29,30,31. TP 26,27-28,29. Pigment reddish or dark (bleached in alcohol). Spermathecae dorsal. Calciferous glands in 11 and 12.

Distribution: Southern Apellachians USA; as with *Bimastos*, a wholly North American genus. Just two species are currently known, others probably extingushed by glaciation.

Remarks: The genus was only briefly covered because of single records of *Es. carolinensis* in Germany and of a possible quarantine interception mentioned by Gates (1972) for *Eisenia pearsei* Stephenson 1933 originally from Durham, North Carolina, known only from the original description and now in synonymy of USA native *Eisenoides carolinensis* (Michaelsen, 1910) – see Gates (1955: 6).

***Eisenoides* key** after Smith (1917: 159); Gates (1955: 1, 1956: 18, 1972); Schwert (1990: 353):

Clitellum on 23,24-30; TP on 26-28,½29, three pairs of spermathecal pores dorsal in 8/9/10/11; pigment deep violet to slate grey but paler laterally in 8-12, semiaquatic .... ***Es. lonnbergi*** (Michaelsen, 1894) [see Michaelsen, 1900: 475; Smith, 1917: 164 for description from Georgia (Savannah) and North Carolina (Raleigh); also Gates 1942: 102, 1955: 1-6 and 1956: 20]. Widespread in Georgia, NC, Maryland, Virginia, Massachusetts, Connecticut, Tenneessee, New Jersey.

Clitellum on 24,25-30,31; TP on 27-29; two pairs of spermathecal pores dorsally in 9/10/11; colour reddish dorsally or absent, moist terrestrial habitats …. ***Es. carolinensis*** (Michaelsen, 1910).

Eisenoides carolinensis (Michaelsen, 1910)

Eisenia carolinensis Michaelsen, 1903: 12, 13, 137. Nomen nudum.

Helodrilus (*Eisenia*) *carolinensis* Michaelsen, 1910: 15; Smith, 1917: 165. [From Fayetteville, North Carolina (NC), intercepted in a plant shipment at Hamburg, Germany. Types Hamburg 5893].

Eisenia pearsei Stephenson, 1933: 936, fig. 28. [From Durham, NC. Types BMNH: 1932:6:24:34-37]. *Bimastos pearsei*: Gates, 1972 (lapsus?) [non cavernicolous *Balanteodrilus pearsei* Pickford, 1938 from Yucatan, Mexico].

Eisenia carolinensis : Cernosvitov, 1942: 222 (describing 14 specimens, 5 immature, in British Museum from Durham, NC); Gates, 1955: 6 (syn. *pearsei*); 1956: 18; European DAISIE website (www.europe-aliens.org/), 2012.

Eisenoides carolinensis : Gates, 1969: 307, 1982: 27; Blakemore, 2004: 75, 2008: 6 (syn. *pearsei*).

Notes: Sometimes miscited as "*Michaelsen, 1902*" rather than "(Michaelsen, 1910)".

Diagnosis: Body square in section after segment 12 with setae at each rounded corner; a reddish rosy colour in life, soon bleached. Length 80-105 mm. Segments 62-152 (Gates). Prostomium epilobic. Setae closely paired (aa:ab:bc:cd:dd = 4:1:3:1:6). Clitellum pale 24,25-30,½31,31 i.e., within 24-31. Tubercula Pubertatis on ca. 27-29 widely lateral of setae b lines. Tumidity obscures ventral setae on some of 10-17 and 22-31. Dorsal pores from 5/6. Spermathecal pores paired in 9/10/11 close to mid-dorsal line. Female pores lateral to b setae on 14. Male pores wider than b setae on 15. Septa 5/6-14/15 slightly thickened. Spermathecae in 9 and 10? (cf. 10 and 11 in some earlier accounts). Testis and funnels iridescent in 10 and 11. Seminal vesicles in 9-12 (weaker in 9 and 10). Ovaries in 13. Hearts in 7-11. Nephridial bladders procilinate U-shaped. Calciferous glands large and moniliform in 11 and 12. Crop in 15 and 16; muscular gizzard in 17-18. Gates (1955) found nematodes in segments 10-11 of one worm whilst gregarine cysts were noted in posterior segments in several posterior amputees that he thought seemed not much capable of regeneration.

Distribution: USA [e.g. North Carolina, Tennessee, Virginia including Whitetop Mountain: "*Under rocks at summit, 4-0-4. Under bark of log at elevation of 4,700 feet, 0-0-1.*" (these numbers are Gates' maturity codes) and in a barn, a dell, and a bog at Mountain Lake – Gates (1956: 18); from Lousiana, Pennsylvania (e.g. Bake Oven Knob), Maryland, Indian Gap in Great Smoky Mountains, Tennessee @ 5,000' – Gates (1955: 7), southern Appalachian mountains of Eastern Kentucky (Kalisz & Dotson, 1989),

Illinois and Tall Timbers Research Station website (www.talltimbers.org) includes specimens from Leon, Florida]. Habitats vary from moist loamy soils, peaty (pH 4.5) to stony (Gates). Apart from the shipment specimen intercepted at Hamburg a 100 yrs ago, not recorded elsewhere outside USA (although it is remarkably similar to *Eisenia gaga* Blakemore, 2012, itself similar to the likes of *E. koreana* – see fig & photo from Blakemore et al., 2012).

Remarks: Whereas seminal vesicles in his specimens were absent from segment 10, Gates (1955: 10) also said that presence of seminal vesicles in 10 in one (or more?) of the types of *pearsei* is about all that remained to distinguish it from *carolinensis* proper and that this did not warrant taxonomic recognition. Moreover, Smith (1917) and Gates (1955: 9) both have spermathecae (anteriorly) in 10 and 11, and Gates (1956: 19) found spermatophores attached at 25/26 and on right side of segment 27 of one worm.

Gates (1982) also queried how this supposed American endemic genus could have survived glaciation there and yet not occur naturally on the Pacific coast nor on the central Prairie lands where many exotic lumbricids now flourish, albeit much aided by European expansion and irrigation.

Recent molecular reanalysis of a voucher specimen (17160 = KX651140) by Csuzdi *et al*. (2017: fig. 1) differs by BLASTn from voucher FJ214226 (from USA in 2008 study by S. Davidson) by 20%, i.e., different taxa. Thus one or both identifications are mistaken (probably the latter as was questioned by Blakemore 2012: 303). Neither yet complies with *Eisenia gaga* or *Eisenia koreana* COI mtDNA from Blakemore (2012).

Genus ***Eophila*** Rosa, 1893

Eophila Rosa, 1893: 10; cf. Omodeo (1988).

[Syn. *Heraclescolex* Qiu & Bouché, 1998: 140 – this genus was poorly differentiated from the prior genera *Allolobophora* Eisen, 1874 and/or *Eophila* but, because type-species of *Heraclescolex*, viz. *Allolobophora moebii* Michaelsen, 1895, was accomodated in *Eophila*, it was made "**syn. nov.**" of *Eophila* by Blakemore (2004: 99). More recent placement of this type-species, *A. moebii*, in synonymy of *Allolobophora molleri* Rosa, 1889 by Trigo *et al.* (1990) is not accepted here and *molleri* is retained, at least provisionally, in *Eophila* along with 8 subspecies. Both *moebii moebii* (Michaelsen, 1895) and *molleri* (Rosa, 1889) were placed in *Eophila* by Easton (1983: 481), and several new subspecies of these proposed by Qiu &

Bouché (1998) were transferred from *Heraclescolex* to *Eophila* by Blakemore (2004: 100). Independently, Csuzdi & Zicsi (2003: 102) reversed Qiu & Bouché's attempted placement of *Ap. dubiosa* in *Heraclescolex* cf. its placement in *Eophila* herein, and Csuzdi & Zicsi also further noted that Qiu & Bouché's genus was not "*robust enough*" taxonomically].

Type-species: *Allolobophora tellinii* Rosa, 1888.

Sub-genus: *Trapezonscolex* Qiu & Bouché, 1998a: 181 (type-species: *Eophila cavazzutii* Omodeo, 1988) [misspelt "*Trapezouscolex*" in Qiu & Bouché, 1998: 88, cf. pg. 187]. Note this probably metits elevation to separate genus level for its two species: *Trapezonscolex cavazzuttii* Omodeo, 1989 and *T. pascuorum* Omodeo, 1989.

Taxanomic notes: Omodeo & Rota (2004: 230) claim that *Alpodinaridella* Mrsic, 1987; *Italobalkaniona* Mrsic & Sapkarev, 1988; *Karpatodinariona* Mrsic & Sapkarev, 1988 and *Serbiona* Mrsic & Sapkarev, 1988 are new synonyms of *Eophila*, but they apparently avoided inspection of types (except for "*topotypes*" that are ungoverned by ICZN, 1999) and they overlooked the sub-genus and the *Heraclescolex* synonym. Moreover, Omodeo & Rota (2004: 230) overlooked the *Dinaridella* sub-genus of *Alpodinaridella* as well as Easton's prior *Perelia* synonymy. Conclusions of these authors are therefore not wholly acceptable, pending further review based on inspection of types and throrough literature searches, thus the genera are maintained.

Diagnosis: Vague due entirely to the confusion with synonyms mentioned above. Perhaps 'key' characters are some of the following:- pigment present or absent; setae often closely paired; small male pores on 15; seminal vesicles in 9-12; spermathecae usually present; calciferous glands pouched in 10 or 11; nephridial bladders U- or J-shaped (cf. *Allolobophora*). Ecologically classed as humus-feeding forest taxa.

Distribution: SW Europe; the *Eo. molleri/moebii* spp-complex has wider distribution by introduction. A mystery worm from Tasmania, *Eophila eti* Blakemore, 2008, is provisionally placed in this genus pending its revision on more mature specimens – its description is presented below as it is likely that it will ultimately be determined an exotic.

Qiu & Bouche (1989: 140) include *Criodrilus dubiosa* Orley, 1881 and *Enteriosn ictericum* Savigny, 1826 in their *Heraclescolex* , here *Eophila*, and thus both should probably be transferred to *Eophila*, thereby expanding its definition and range (pending).

<u>Key to widespread species:</u>

Spermathecal pores absent, dorsal pores from 9/10/11 ……. *Eophila eti*

Spermathecal pores from 7/8, dorsal pores from 4/5 or 5/6 …. *Eophila molleri/moebii*

Eophila eti Blakemore, 2008

Fig. 6.18 *Eophila eti* Blakemore, 2008. Holotype, aclitellate (subadult?), ventral view of body, with nephridial bladders in 7lhs and 23lhs, ovaries in 13lhs, and gut from calciferous glands to gizzard also showing hearts. Dorsal views are of anterior (prostomium) and posterior (pygidium). Setal ratio on 12 is shown as a,b,c,d.

Eophila eti Blakemore, 2008: 4, fig. 1. [Dalgarth Forest Reserve, north Tasmania. Type QVM 14:1494].

Material examined: Dalgarth Forest Reserve, north Tasmania 41°41'S.146°34'E (Tamar EQ 707-343), 120m asl, 30.vi.1992. Collector, R.D. D'Orazio. QVM 14:1494 Holotype, H (75 mm long, here figured, dissected and described); other material from same batch – two aclitellate syntypes identified here as S1 (62 mm long, dissected) and S2 (80 mm long, undissected).

Habitat: woodland "*wet sclerophyll to rainforest*".

Species from same locality: *Graliophilus praestringor* Blakemore, 2000; *Vesiculodrilus oeconomicus* Blakemore, 2000; and *Notoscolex dorazioi* Blakemore, 2000 (all natives).

Behaviour: Not recorded, but being unpigmented with organic soil in its gut suggests it is neither a litter species nor a subsoil species, most likely a topsoil dwelling species.

Body length: 62-80 mm. Body cylindrical throughout and mostly turgid.

Width: 2 mm.

Segments: 140 (H).

Colour: Unpigmented or milky white in anterior but after segment 14 the cuticle becomes almost transparent.

Prostomium: Open epilobous.

First dorsal pore: 10/11 and possibly rudimentary or minute in 9/10 (H), or 11/12 (S1).

Setae (ratio of aa:ab:bc:cd:dd:U): Closely paired in regular rows from 2; (ca. 5:1:2:1:9:0.5?). Several reserve setae in bundles of about 5 each in ab and 4 in cd noted in segments 9-11 from internal inspection seen only in H (not in S1). Ventral couples on 16 and 17 within slightly tumid pads.

Nephropores: Not found.

Clitellum: Ill-defined possibly absent or as faintly saddle-shaped to b-lines from 16 to

around 32.

Male pores: Not found.

Female pores: Not found - minute on 14 or possibly intersegmental in 14/15 (from oviducts).

Spermathecal pores: Not found but very small pores appear in c lines in 9/10/11 although nothing corresponds internally.

Genital markings: Absent although a pair of small dish-like depressions possibly with a minute central pore lateral of b setae on 15; setae ab on 16 and 17 slightly tumid. No glands or other structures appear internally to correspond with any of these pads.

Cerebral ganglia: Paired in 2 with small nerves projecting to prostomium.

Pharyngeal mass: In 3-5.

Septa: 4/5-10/11 only slightly thickened. No septum divides gizzard in 17-18.

Dorsal blood vessel: Extra-oesophageal trunks pass to dorsal trunk in 12.

Vascularization: Dorsal blood vessel single onto pharangeal mass in 3, supra-oesophageal vessel absent, ventral blood vessel on ventral nerve cord but not connected to it except where they join at septa; commissurals small in 6, large hearts paired in 7-11.

Alimentary canal: Large pharyngeal pads internally in 3-4, oesophagus has annular calciferous sacs with wider lip from half 10 and internal striations from 11-12,13, other striations in 14 may mark transition to oesophageal valve.

Gizzard: Intestinal crop dilated in 15-16; muscular gizzard in 17-18; from about 20 a wide and thick lamellar typhlosole develops.

Nephridia: Holoic, nephridia rudimentary in 3-4, from 5 onwards large elongate (sausage-shaped) vesicles from median of ab setal pairs overlie coiled nephridial tubules (perhaps entering body wall ventral of ab setae).

Male organs: Holandric; seminal vesicles elongate, saccular posteriorly in 9 and 10, and larger anteriorly in 11 and 12; testes and funnels in 10 and 11 (free?).

Ovaries: In 13, cup shaped and palmate without single egg-strings; funnels posteriorly; a small pair of ovisacs in 14 anteriorly.

Prostates: None.

Spermathecae: None found in 8-10, nor elsewhere in anterior of body.

Gut contents: Some grits and woody material but mainly organic soil and debris.

Etymology: "*eti*" genetive abbreviation from *ex terrestris* referring both to its terrestrial rather than aquatic habitat and its obscure but assumed distant homeland (like ET!).

Remarks: On balance, based on its characters, this species is considered a member of

Lumbricidae that is considered endemic to the holarctic. It does not clearly fit into current generic definitions (e.g. Michaelsen, 1900; Sims & Gerard, 1985; 1999; Csuzdi & Zicsi, 2003), that apply to similarly immature or to mature specimens, coming perhaps closest to *Eisenia* Malm, 1877, *Helodrilus* Hoffmeiseter, 1845, or *Dendrobaena* Eisen, 1873/4. It is compared to *Dendrobaena rubidus* (Savigny, 1826) but is provisionally attributed to the ill-defined genus *Eophila* Rosa, 1893 rather than the earlier *Helodrilus* that generally defines species lacking nephridial bladders. Its unique features appear to be the pads in segment 15 that are more usually associated with male pores in this segment in most lumbricids while the arrangement of the calciferous glands and intestinal gizzard are similar to those in *Dendrodrilus rubidus* species-complex. However, the nephridial bladders in *Dendrodrilus* are U- or J-shaped rather than sausage-shaped as in *Eisenia* and in the current species. For these reasons it is considered a unique species, at least amongst the cosmopolitan lumbricids, and it given a name in anticipation of further specimens providing a fuller description (e.g. of clitellar extent). Although attributed to family Lumbricidae, some characters, such as the reserve setal bundles are unusual, while others appear intermediate with affinities perhaps to the Criodrilidae for *Criodrilus* as redescribed by Blakemore (2007) or to *Drilocrius* Michaelsen, 1917 (Family Almidae). However species in the families Criodrilidae and Almidae are aquatic and generally lack anterior nephridia and dorsal pores (except in possible synonym *Hydrilus*), and have neither gizzards nor calciferous glands. Confirmation of identity requires further material from the type locality or from further abroad.

Explaining this species' origins, if found to be a true Tasmanian native, would require substantial revision of theories of earthworm palaeobiogeography with confinement of Lumbricidae to Laurasia, but this outcome is highly unlikely.

Eophila molleri/moebii species-complex.

Remarks: *Eophila moebii* (Michaelsen, 1895) and its possible senior synonym, *Eo. molleri* (Rosa, 1889) have been reported from the Iberian peninsula, Algeria e.g. by Baha (1997), Morocco (Tangiers), Madeira, the Canary islands (Ref.) and both are introductions to Mexico (Gates, 1970; C. Fragoso pers. comm.; Brown & Fragoso, 2007). However, *Eophila moebii moebii* (Michaelsen, 1895) is ***species inquirenda*** placed either in syonymy or as a part of an *Eophila molleri molleri* (Rosa, 1889) species-complex,

itself sometimes placed in *Aporrectodea*, e.g. by Trigo *et al.* (1990: 535) or *Allolobophora* s. lat., e.g. by Csuzdi & Zicsi (2003: 234). But, because fates of many of their 8 subspecies were undecided, it was temporarily retained, as here, in *Eophila* by Blakemore (2004; 2005; 2007).

Diagnoses after Michaelsen (1900: 487), who had them both in sub-genus *Helodrilus* (*Allolobophora*), are:

Eophila molleri mollerii (Rosa, 1889: 3) [From Portugal. Types?]. [Syn. *moebii tenerifana* Cognetti, 1931 again with uncertain types]. Colour a dark green. Clitellum from 48,49-59 with TP 50-57. Setae *ab* on 12, 13, 14 and sometimes 20 in tumid pads. Dorsal pores from 4/5. Spermathecal pores two pairs in 7/8/9 in *cd* lines. Size 150 mm by 4 mm. Segments 150-210.

Its 5 sub-species, from Blakemore (2007, 2008), are:-

Eo. molleri abylana (Qiu & Bouché, 1998: 142) (originally spelt "*abylanus*").

Eo. molleri molleri (Rosa, 1889) [syn. *Allolobophora fernandae* Graft, 1957 by Trigo *et al*. (1990: 535); cf. *Eo. moebii*].

Eo. molleri palmensis (Qiu & Bouché, 1998: 143) [non *Postandrilus palmensis* Qiu & Bouché, 1998].

Eo. molleri salobrenana (Qiu & Bouché, 1998) (originally spelt "*Heraclescolex molleri salobrenanus*").

Eo. molleri sefia (Qiu & Bouché, 1998: 141) [originally spelt "*Heraclescolex molleri sefia*" (sic); misspelt "sifia" by Bouché *et al.* (2004: 391)].

Eophila moebii moebii (Michaelsen, 1895: 4) [From Madeira. Types?]. [Syn. *Allolobophora fernandae* Graft, 1957: 302; types in Lisbon]. Colour pale or goldish. Clitellum from 52,53-61,62 with TP 55,56-61,62. Dorsal pores from 4/5/6. Spermathecal pores three pairs in 7/8/9/10 in *cd* lines. Size 60-125 mm by 4-5 mm. Segments 104-122.

Its 5 sub-species from Blakemore (2007) are:-

Eo. moebii moebii (Michaelsen, 1895) ***species inquirenda*** [syn. *moebii tenerifana* Cognetti, 1931; formerly in *Allolobophora*, *A. moebii* was placed in syonymy of *A. molleri* by Trigo *et al.* (1990: 535) but because the fates of the subspecies were undecided, it is retained in *Eophila*, at least temporarily, as per Easton

(1983)].

Eo. moebii baeticae Sims, 1962 [misspelt "baetica" in Qiu & Bouché (1998: 189)].

Eo. moebii dehensis (Qiu & Bouché, 1998: 145).

Eo. moebii michaelseni (Qiu & Bouché, 1998: 146).

Eo. moebii talaverai (Qiu & Bouché, 1998: 144) [**Emend.** Originally misspelt by Qiu & Bouché (1998: 144) as "talavarai" and later (1998: 189) as "talavarei", under ICZN (1999: Arts. 19.3, 24.2.3, 32.2.1, 32.4) the name was formally fixed by Blakemore (2004: 100) as *talaverai* as the authors' state the name is for a Dr Talavera Sosa].

Genus ***Helodrilus*** Hoffmeister, 1845

Helodrilus Hoffmeister, 1845: 38 (Regenwürmer); Michaelsen, 1900: 486 (Tierreich). [Syns. *Helodrylus* D'Udekem, 1855 (lapsus pro *Helodrilus*); *Anagaster* Friend, 1921 (type-species: *Anagaster fontinalis* Friend, 1921 (= *H. oculatus*) from Easton (1983))].

Type-species: *Helodrilus oculatus* Hoffmeister, 1845 by original designation.

Taxonomic Note: Emendation (of the name?) is claimed by Michaelsen (1900: 495) and Omodeo (1953), but the only known *lapsus* in original spelling was *Helodrylus*.

Diagnosis: Setae extremely closely paired. Calciferous gland opens directly into the oesophagus in segment 10 (or in some, or all ,of 11-14), calciferous sacs absent (Sims & Gerard, 1999) or with lateral diverticula in 10 sometimes hardly recognizable (Csuzdi & Zicsi, 2003: 169). Nephridial vesicles absent (mostly?). Nephropores obvious in single row along each side of body (Sims & Gerard, 1999) or hardly visible (Csuzdi & Zicsi, 2003: 169). Pigment not red. Muscle layer fasciculated.

Basic chromosome number is n=18 (Gerard, 1964: 45).

Distribution: Palaearctic e.g. Balkans (Ref.) possibly through to Japan (one species – *He. hachiojii* Blakemore, 2007). Only two species can be regarded as widespread peregrines: *He. oculatus* and *He. cernosvitovianus* (Zicsi, 1967); the former species is described below, the latter species is recorded from mineral soil in moist clays from Hungary, and from Ukraine, Serbia, Greece and Poland (Csuzdi & Zicsi, 2003: 171). Because *He. hachiojii* may prove to be an introduction to Japan, it is described below.

Gates (1972: 108) said that his synonymy in *Aporrectodea rosea* of *Helodrilus indicus* Michaelsen, 1907 was not accepted by all authors, indeed Easton (1983: 478)

appears to have ressurected this taxon and transferred it as *Dendrobaena indica*; this synonymy was also rejected by Cs. Csuzdi, pers. comm. (cf. genus *Healyella*).

Regardless of its generic status, *He. indicus* Michaelsen, 1907 (or D. *indica* or *Hy. indica*) can no longer be thought an endemic to India and thus neither is the family Lumbricidae.

The taxa briefly considered below are tentative exotics in *Helodrilus*.

Key to Widespread/Transported *Helodrilus* species TP – Tubercula Pubertatis.

Clitellum in 21,22-28,29 and TP in ½26-½28 ….. *H. cernosvitovianus* European (see Csuzdi & Zicsi, 2003: 171 for description and distribution of this subsoil species).

Clitellum 21,22-32; TP 28,29-30,31 ……..... *H. oculatus* - widespread.

Clitellum 23-31; TP paired papillae on 29 … *H. hachiojii* - transported/native to Japan?

Clitellum 25-32; TP 26-30 ….....…..... ?*H. indicus* - uncertain placement.

Eisenia hachiojii (Blakemore, 2007)

Fig. 6.19. *Eisenia hachiojii* Holotype from Komiya-koen, Hachioji, west Tokyo [SV, seminal vesicles; T, testes; F, testis funnels; DP, dorsal pores; TP, tubercula pubertatis, TYP, typhlosole; figure also shows prostomium, nephridia (plus enlargements) and posterior].

Helodrilus hachiojii Blakemore, 2007 (Edaphologia **82:** 17, December, 2007). [From Hachioji. Types in Tokyo NSMT-An 371, 372-3, 374-6].

Eisenia hachiojii : Szederjesi *et al*. 2014: 184.

Diagnosis: Length 50-70 mm. Lightly pigmented brown dorsum, pinkish. Anterior body cylindrical, posterior flattened rectangular. Prostomium epilobous. First dorsal pore 4/5. Setae closely paired, in anterior at least. Spermathecal pores not found. Male pores confined to 15. Clitellum saddle-shaped 23-31. Tubercula pubertatis in form of paired papillae on 29 lateral of setae b. Calciferous glands in 11-12 (and 13-14). Nephridia holoic, bladders (mostly) lacking. Spermathecae lacking.

Material examined: NSMT-An 371 – H clitellate mature, dissected and sketched (Fig. 1), An 372-3 – P1-2 two sub-adults - dissected, An 374-6 – P3-5 an aclitellate juvenile and two immatures all lacking tubercula pubertatis - inspected. A single specimen from north of the lake deposited in Lake Biwa Museum, undissected but externally it complies with *H. hachiojii*, LBM: 1380000005 ex Accession Batch Number FY2007-11; other

Biwa specimens in 2009 surveys including from drain near old farmhouse at Shinme and from 2.II.2011 from paddy walkway (aze) at Kaideima-cho, Hikone near Biwa (An-459).

Locality: From Komiya Park, Hachioji (小宮公園 八王子市), western Tokyo ca. 35°40'N.139°19'E (collected by R.J.B. 22.x.2004). An additional single specimen, collected 4.x.2007 by R.J.B. from moist mud of harvested rice paddy opposite *konbeni* store *en route* to Saugura at Shiotsuhama, Nishiazai-cho, northern Lake Biwa, Shiga-ken plus several other specimens from Lake Biwa noted above.

Habitat: In mud beside creek draining spring-fed moat of Otanibenzaiten shrine (大谷弁財池). [Location photos March, 2007]. A later 2009 Lake Biwa trip found several specimens in moist soil of rice paddy and under water in drain (e.g. at Hikone, Ohtsuka).

Species associations: From same Hachioji collection site, small microdriles (tubificids?) and large pheretimoid megadriles – members of the *Amynthas corticis* (Kinberg, 1867) species-complex *sensu* Blakemore, 2003. Lake Biwa site had pheretimoids, lumbricids, *Drawida* and ocnerodrilids present plus leeches (see Blakemore, 2008, 2010, 2011).

Behaviour: Limicolous (mud-dwelling); unresponsive or docile to touch (no thrashing).

Lengths: 69 (H), 60 (P1), 50 (P2), 55 (P3), 40 (P4), 30 (P5); range adults 60-70 mm.

Width: 2.5-3.0 mm.

Body: Body cylindrical in anterior and dorso-ventrally flattened in final 30 or so segments of posterior to become almost rectangular in section with setal pairs at corners; segmental counts 105 (H); range c. 100-125.

Colour: Unpigmented pink with yellow clitellum and blood vessels and intestinal digesta visible through cuticle in life; anterior lightly pigmented brown, clitellum pale buff otherwise bleached white in ethanol.

Prostomium: Closed epilobous.

First dorsal pore: Rudimentary in 3/4 (H), wide open from 4/5 (H, P1-2).

Setae: 8 per segment from 2; small, black and closely paired in anterior with ratio aa:ab:cd:dd:U (U= circumference) approximately 4:1:3:1:14:0.5 (see figure); in posterior, gaps widen and in last 30 or so segments setae larger and opaque with ratio d:d less than half circumference; no setal tumescences noted.

Nephropores: Inconspicuous (internally nephridia duct near ventral setal couples).

Clitellum: Saddle-shaped to mid-bc in 23-31 (H), not fully developed but some dorsal modification in (21,)22-30,31 in (P1); range thus possibly 22,23-30,31.

Male pores: Small, equatorial, non-tumid and confined to 15 in mid-bc lines.

Female pores: Minute in 14; determined to be lateral of b setae from internal ducting.

Spermathecal pores: Not found, absent.

Genital markings: Tubercula pubertatis in form of a pair of discrete raised papillae ventrally on 29 just lateral to b setae (no glands correspond internally); no other banding.

Septa: With some thickening in anterior to 13/14 thereafter thin; septum 17/18 to mid-gizzard reduced or aborted.

Vascularization: Hearts paired in 7-11; dorsal blood vessel single; some vessels ventrally on calciferous glands, but not notably well supplied dorsally. Sub-neural vessel or oesophageal vessels not found.

Calciferous glands: Large annular with deep intramural striations in 11-12 (striations continue to a lesser degree in 13-14); no extramural sacs or diverticula.

Intestines: Oesophageal valve in 14/15, large thin walled and dilated crop in 15-16, muscular gizzard large in 17-18 and just encroaching into 19, intestinal origin 19, typhlosole simple lamellar commencing from about 22-23; caeca absent.

Nephridia and vesicles/bladders: Holoic (i.e., two per segment) noted from 6 or 7 onwards (possibly small and concealed in oesophageal mass further forwards?); bladders generally absent but a few nephridia have simple flask-shaped bladders (at least in ca. 8rhs and 20lhs in H only, and some similar bladders also in one or two other segments in gregarine infested P2, but none seen in P1; however Szederjesi *et al*. (2014) found small, saccular bladders in all segments in topotype HNHM/15531); pre-septal funnels with terminal ducts near ventral setal couples and no canalization to intestine. Nephridia were classed as mostly lacking bladders i.e., avesiculate and belonging to *Helodrilus*. However, 2009 Lake Biwa specimens appeared to have bladders more frequently, but again not in all segments thus compliant with *Eisenia* as per Szederjesi *et al*. (2014). (Note that bladders are perhaps superfluous in aquatic or semi-aquatic species).

Male organs: Vasa deferentia traced to non-iridescent funnels in 10 and 11, small testis possibly free in 11 (not clearly distinguished in 10); seminal vesicles paired: small and vestigial posteriorly in 9 and anteriorly in 11; larger posteriorly in 10 and anteriorly in 12; these characteristics imply infertile holandry with incipient metandry.

Ovaries: Small paired saccular with funnels in 13; small or vestigial ovisacs paired anteriorly in 14.

Prostates: None.

Spermathecae: None found.

Longitudinal muscuature: Not determined.

Gut contents: Fine organic material and dark soil (mud) consistent with habitat.

Cocoons: None found.

Parasites: Heavy infestation with gregarine *Monocystis* sp. cysts in body cavity of dissected (P2) and seen through body wall of (P3).

Remarks:

1. The specimens' location (mud), species-association with microdriles, nephridia reduced in anterior and lacking bladders, and the gut contents are all indicative of a semi-aquatic or limicoline habitat; but presence of dorsal pores and gizzard muscular rather than atrophied, as would be expected, suggest adoption of this habitat is fairly recent.
2. Non-iridescent testis/male funnels, absence of spermathecae or spermatophores, minute male pores and parasitism of reproductive organs indicate parthenogenesis.
3. Small size, parthenogenicity with associated tolerance of higher parasite burden, high proportion of juveniles, and species association (e.g. cosmopolitan *Amynthas corticis*) in a locality disturbed by human activity (the moat was dug as an emergency water supply according to a local information board) and rice paddys, all suggest exotic origin.
4. Conversely, its narrow distribution (just two localities in Japan but these far apart and obviously expected in intervening region) and no other similar species on record suggest this is a species new to the Japanese faunal list. It may yet be shown to be a parthenogenetic morph related to *Eisenia japonica*.
5. This suspicion was confirmed when Szederjesi *et al.* (2014) transferred it to *Eisenia*.

Table 1' and Table 2' compare it with similar lumbricids and with *H. oculatus*.

Table 1'. Characters of *Eisenia hachiojii*, *E japonica* (morphs), *E. koreana* and *E. nordenskioldi* sub-spp (from Blakemore, 2003, 2006b; Zicsi, 1972)

	E. hachiojii	***E. japonica***	***E. koreana***	***E. nordenskioldi***
Length mm	50-70	(24)42-102(175)	42-105	25-150
Segments	100-125	(85)96-140(151)	87-165	80-176
Colour	Unpigmented or pink/brown	Anterior pink/brown	Grey brown	Puce or pallid
Clitellum	22,23-30,31	23,24-31	25-31	26,27-33,34
TP	29	27 or 27 and 29	27-29	29-31,32
Shape of TP	Round or slight elongate	Round-triangular	Elongate	?
Nephridial bladders	Absent (mostly) or small flasks	Sausage-shaped throughout	Sausage-shaped	Sausage-shaped
Spermathecae	No	In 9/10/11	In 9/10/11	In 9/10/11

Habitat	Semi-aquatic	Terrestrial	Aquatic?	Terrestrial

Table 2'. Characters of *Eisenia hachiojii* and type-species *Helodrilus oculatus

Characters	***E. hachiojii***	***He. oculatus***
Length (mm)	60-70	35-80
Segments	100-125	90-150
Colour	Light brown	Unpigmented with some black dots
Setae	Closely paired; no tumescences	Very closely paired, black; tumescences around ab on (10)11(12)
Calciferous glands	11-14 (annular)	10 (saccular, Sims & Gerard, 1999)
Clitellum	22,23-30,31	21,22-32
TP	29	29-30 (or 30-31, Perel, 1997: 55)
Shape of TP	Round	Elongate, continuous
Seminal vesicles	Four pairs in 9-12	Two pairs in 11 & 12
Posterior section	Rectangular	Circular
Spermathecae	None (parthenogenetic)	In 9/10/11(/12) in setal c lines
Longitudinal mucle	?	"fasciculated"
Nephridial bladders	Absent (mostly)	Absent (some replaced by canals?)
Characters	***He. Hachiojii***	***He. oculatus***

TP – tubercula pubertatis.
* *H. oculatus* described in more detail below.

Helodrilus indicus Michaelsen, 1907

From Calcutta, types (five of) in Indian Museum. Subsequently placed in synonymy of *Ap. rosea* by Gates (1958: 6,1972) or transferred separately to genus *Dendrobaena* by Easton (1983), or cf. *Healyella* (by Csuzdi pers. com.). The full original description (cf. *Ap. rosea* above) from Michaelsen (1907: 188) was:

"*Helodrilus (Bimastus) indicus n. sp.*
Länge (42 ?) 58—75 mm. max. Dicke ca. 6 mm, Segmentzahl (87? —) ca. 107.
Färbung grau; pigmentlos.
Kopf epilobisch (2/3).
Erster Rückenporus auf 5/6.
Borsten eng gepaart; aa = bc = 3/5 dd; ab = cd = ca..1/5 aa.
Gürtel sattelförmig, an 25— 32 (=8), an 32 schwächer ausgeprägt.
Pubertätsorgane: Drüsige polsterförmige Modifikation am unteren Rande des Gürtels an 26—30, im allgemeinen a medial ein wenig überragend, b lateral weit überragend, an 26 kleiner, a freilassend.
Männliche Poren scharfe Querschlitze auf 15 zwischen b und c, ersteren genähert, auf breiten Längswülsten, die medial sanft. lateral ziemlich steil abfallen und sich über 14—16 erstrecken.
Kalkdrüsen nicht scharf ausgeprägt; Muskelmagen im 17. bis 18. Segment.
Zwei Paar große Samensäcke von Dissepiment 10/11 und 11/12 in das 11. und 12. Segment hineinragend.
Samentaschen fehlen.

Bengalen, Calcutta; N. ANNANDALE leg."

Helodrilus oculatus Hoffmeister, 1845

Fig X. *Helodrilus oculatus* after Sims & Gerard (1999, fig. 31); copied here.

Helodrilus oculatus Hoffmeister, 1845: 39. [Type locality Germany. Types not known]; Beddard, 1895: 174; Michaelsen, 1900: 497 (syn. *hermanni*); Gerard, 1964: 45; Sims & Gerard, 1985, 1999: 94, fig. 31; Perel, 1979: 180, 1997: 55; Qiu & Bouché, 1998.

Allolobophora hermanni Michaelsen, 1890: 13. [Types missing].

Anagaster fontinalis Friend, 1921: 139. [From Suffolk, poorly described and attributed by its author to the Criodrilinae. Types missing].

Eophila oculata : Dobson & Satchel, 1956.

Allolobophora oculata : Mrsic, 1987.

Helodrilus oculatus oculatus : Easton, 1983: 483 (syn. *hermanni* Michaelsen, 1890; *fontinalis* Friend, 1921); Blakemore, 2004; 2005; 2006; 2007 (syns. as above).

Helodrilus phillipei Qiu & Bouché, 1998: 12, fig. 4. [French location and collector unknown "*au lieu ECORDRE P. 1994*". Types CO-ECO 111/1994/4551 – holotype and paratype given the name rego.]. [Sometimes misspelt "*philippei*"]. **Syn. nov.**.

Taxonomic Notes: Easton (1983) has subspecies: ***H. oculatus samniticus*** Cognetti, 1914 [Type in Turin: 805, syns. *oculatus dudichi* Pop, 1943; *massiliensis* Bartoli, 1962] that is sometimes given separate species status as *H. samniticus*.

Diagnosis of *H. oculatus*: Length 35-80 mm. Unpigmented but sometimes pale with scattered black markings (once thought of as "*eye spots*" – hence its name). Body cylindrical. Prostomium epilobous. First dorsal pore 4/5. Spermathecal pores in 9/10/11 (or 9/10-11/12) immediately below c lines. Clitellum saddle-shaped 21,22-32. Tubercula pubertatis ovoid longitudinal ridge on 28,29-30,31 along ventral border of clitellum; tumescences around ab on some of (10), 11, (12). Setae closely paired (some black?). Male pores lateral of b setae on 15 within large tumescences extending 13/14-16/17. Seminal vesicles paired in 11 and 12.

Distribution: Western Palaearctic, western and eastern Europe, e.g. Austria, Denmark, France, Germany, Italy, Portugal and U.K. (Brands, 2006

http://zipcodezoo.com/Animals/H/Helodrilus_oculatus.asp), also Poland and the Russian Federation (but not far east), Czechoslovakia (Pizl, 1985), Slovenia (Mrsic, 1991), the Maghreb (Omodeo *et al.*, 2003) and east Mediterranean (Csuzdi & Pavlicek, 2005), these latter authors also note that in a report from Turkey by Omodeo & Rota (1989, 1991) the species is described with clitellum on 21,22-32,33 and tubercles on 29,30-32,33 which is identical with *H. patriarchalis* (Rosa, 1893) that is common in the Levant and Cyprus but not in Anatolia (Csuzdi, 2007). Found "*teeming*" in black mud beneath the Thames around London (Friend, 1911), "*at a depth of from 100 to 150 feet*" in Lough Mask, Co. Mayo, Eire (Friend, 1911: 14); and in a "*Roman ditch*" in St Albans, UK (Sims & Gerard, 1999).

A recent and currently unconfirmed/unpublished report is from Virginia, USA by M. Callaham (pers. comm. June, 2013 at SES meeting).

Locality: Specimens from Scotland (collected by Ken Killam?, deposited at Waite Institute, Adelaide inspected by RJB in 1993/4.

Habitat: In running water, ponds, wells or in wet clay and muds (pH 7.0-7.6).

Behaviour: Aquatic or limnic.

Length: 35-80 mm.

Width: 1.5-2.0 mm.

Segments: 90-150. Body cylindrical.

Colour: Unpigmented or flesh coloured occasionally with scattered black markings.

Prostomium: Epilobous.

First dorsal pore: 4/5.

Setae (7/ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired; (7:1:5:1:15:?).

Nephropores: Obvious in single row on each side of body.

Clitellum: Saddle-shaped 21,22-32.

Male pores: Lateral of b setae on 15 within large tumescences extending 13/14-16/17.

Female pores: Lateral to b in 14.

Spermathecal pores: Small paired in 9/10/11 or 9/10-11/12 immediately below c lines.

Genital markings: Tubercula pubertatis ovoid longitudinal ridge on 29 and 30 (Sims & Gerard, 1999) or 28,29-30 or 30-31 according to Perel (1979: 180; 1997: 55) or 28-29 (*phillipei*) along ventral border of clitellum; tumescences around ab on some of (10), 11, (12) usually most pronounced ventally on 11.

Septa: (5/)6/7/8/9 strongly muscular.

Hearts: (7-11).

Gizzard: (Crop 15-16; gizzard 16, 17-18).

Calciferous glands: Open directly into oesophagus in segment 10, calciferous sacs absent (possibly in 11 in *phillipei*). Calciferous lamellae extend midway through 10 to 14.

Intestine origin (caeca, typhlosole): (19; typhlosole simple).

Nephridia: Holoic, bladders absent.

Male organs: Testes/funnels holandric; seminal vesicles paired in 11 and 12.

Ovaries: In 13.

Prostates: None.

Spermathecae: Two small pairs in 9 and 10, or three pairs 9-11 (Michaelsen, 1900: 497).

Gut contents: Mud?

Notes: Chromosome number 2n = 32 (Gerard, 1964:45). "*Populations often consist almost entirely of juveniles, which are characterised by the terminal setae not being black*" Sims & Gerard (1999: 94). The records from Verulamium (St Albans) have led to speculations that the species may have been introduced to Britain before or during *Pax Romana* era (Dobson & Satchell, 1956) which seems to me a bit whimsical.

There is nothing of substance to separate *He. phillipei* from *He. oculatus*.

Friend (1919: 446) reported "Helodrilus oculatus *is the only Lumbricid found in England possessing organs of vision, and these are rudimentary. They have been reported by Eisen as occurring in* Sparganophilus *also, two species of which, as I recently showed, occur in this country*". Once again our friend Friend is off track.

Genus ***Lumbricus*** Linnaeus, 1758

Lumbricus Linnaeus, 1758: 647; Michaelsen, 1900; Stephenson, 1930; etc..

[Syns. *Enterion* Savigny, 1822: 100, the genus name enterion, diminutive of *enteron* – entrails, referring to Aristotle's quote about worms being the entrails of the earth (type-species: *Lumbricus terrestris* Linnaeus, 1758) synonymized Sims (1973: 30); *Omilurus* Templeton, 1836 (type-species: *Omilurus omilurus* Templeton, 1836 (= *L. festivus*))].

Type-species: *Lumbricus terrestris* Linnaeus, 1758, designated by Stiles & Hassel (1903: 118) as noted by Sims (1970; 1974: 30) who also fixed the description to a neotype in Natural History Museum London (see note under its account below).

Taxonomic Note: The original earthworm taxon and, because of this, the most confused historically (see Blakemore, 1997). Even today some people describe any 'common' worm as *L. terrestris*.

Diagnosis: Calciferous sacs opening posteriorly into the oesophagus of segment 10 ventrally and just in front of septum 10/11. Calciferous lamellae continued along lateral walls of the sacs. Nephridial vesicles J-shaped. Nephropores alternating irregularly on each side of body above b and d lines. Body trapezoidal in posterior. Pigment red. Prostomium tanylobous. Musculature pinnate longitudinally.

Distribution: Palaearctic, but not in North Africa, Sardinia nor Sicily. Endemic species in central Europe. Three peregrine species are especially widely distributed (*castaneus*, *rubellus*, *terrestris*) and three others are erstwhile peregrine species: *L. festivus* (Savigny, 1826) in Canada and Vermont (Reynolds, 1977:92); *L. friendi* Cognetti, 1904 which is said to be common in Uraguay (Gates, 1972: 113) and in the Washington-Baltimore Metropolitan Area (Csuzdi and Szlávecz, 2003); and the Alpine *L. meliboeus* Rosa, 1884 transported (presumably by humans?) to Swedish Lapland (Piquet, 1919). Levinsen's *Lumbricus eiseni* is now transferred to *Allolobophordiella* following Mrsic, 1990. *Lumbricus baicalensis* Michaelsen, 1900 215 (syn. *dueggelii* Bretscher, 1903, *pusillus* Wessely, 1905) is found in central Europe from Austria to Ukraine, its name mistakenly refers to Lake Baikal due to a mistake of the original labels (Michaelsen, 1901; Csuzdi & Zicsi, 2003).

Basic chromosome number is n=18 with ploidy 2*n*=36 (Gerard, 1964: 46), most species are presumed to reproduce sexually.

Key characters of peregrine *Lumbricus* species

L. castaneus – small sized, tubercula pubertatis on 29-32, broad bands.

L. festivus – medium sized, tubercula pubertatis on 35-38, narrow bands.

L. friendi – large sized, tubercula pubertatis on 34-37, papillate on 34 and 36.

L. meliboeus Rosa, 1884 (syn. *L. michaelseni* Ribaucourt, 1896; often misspelt "moliboeus") – clitellum 28,29-33, tubercula pubertatis 30-32,33. From Sarek, Lapland either in W. Norway on NEAT website or listed with a "?" on SWORM website (from Sweden) thought transported (by humans?), from Austria, Germany, and listed as a non-endemic European species in Montenegro by Stojanovic & Karaman (2003).

L. rubellus – medium sized, tubercula pubertatis narrow bands on 27,28-31,32.

L. terrestris herculeus – medium sized, tubercula pubertatis on 33-36, ridge-like.

L. terrestris terrestris – large sized, tubercula pubertatis on 33-36, ridge-like.

Lumbricus castaneus (Savigny, 1826)

Fig. *L. castaneus* from Sims & Gerard (1999 fig. 32).

Enterion castaneum Savigny, 1826: 180. [Type locality Paris. Types missing from Paris Museum]. [Non *L. castaneus* Risso, 1826 which is listed as *incertae sedis* in Michaelsen (1900: 518), see also Gates (1972: 115)].

Enterion pumilum Savigny, 1826: 180. [Type locality Paris. Types in Paris].

Lumbricus triannularis Grube, 1851: 18. [From Siberia? Types?].

Lumbricus terrestris minor Pennant, 1766: 4, 33, pl. 19. fig. 6A. Types missing. ***Sp. dub.*** [Non *Allolobophora savignyi minor* Stephenson, 1931: 33 (= *Scherotheca*)].

Lumbricus minor : Johnston, 1865: 59 (= *L. pulchellus* Leach in MS?). [Note: Johnston was not the author of the taxon *minor* as he just quoted Pennant, 1766].

Lumbricus josephinae Kinberg, 1867: 98. [St Helena. Types NHRS: 1928 with a specimen labelled "*Lumbricus josephinae Kinberg, 1867 PARA/SYNTYPE 1904:10:5:554 Loc; St Helena Coll: Natuh..Riksmuseet, Stockholm Ref:* "; one specimen in poor condition].

Lumbricus purpureus Eisen, 1871: 956, figs. 3, 34-41. [Types Stockholm & London].

Lumbricus pumilosum (laps. pro *pumilum*) : Beddard, 1895: 722.

Lumbricus castaneus var. *morelli* Ribaucourt, 1896: 13. [Mont Geant. Types?].

Lumbricus castaneus var. *perrieri* Ribaucourt, 1896: 14. [Berne. Types?].

Allolobophora brunescens Bretscher, 1900: 42. [Types in Zurich]. [Sometimes misspelt "brunescene"].

Lumbricus castaneus var. *disjunctus* Tétry, 1936: 196. [Types?].

Lumbricus castaneus var. *pictus* Chandebois, 1957: 417. [Types?].

Lumbricus castaneus: Michaelsen, 1900: 510 [syn. *pumilum*, *triannularis*, ?*minor* (*L. pulchellus* Leach in MS?), *josephinae*, *purpureus*, *morelli* + *perrieri*, *pumilosum* (laps.)]; Tétry, 1937: 151; Gerard, 1964: 46; Stöp-Bowtiz, 1969: 239; Gates, 1972: 114; Easton, 1983: 482 (syn. *pumilum*, *triannularis*, *minor*, *josephinae*, *purpureus*, *castaneus morelli*, *castaneus perrrieri*, *brunescens*, *castaneus disjunctus*, *castaneus pictus*); Sims & Gerard, 1985, 1999: 96, fig. 32: Blakemore, 2004; 2006; 2007 (syns. as above).

Taxonomic Note: Although Reynolds (1977) and Easton (1983) place *disjunctus* Tétry in synonymy, Gates (1972: 115) argues that it should perhaps be elevated to species level – it is thus characterized in **Remarks** below.

Diagnosis: Length 30-70 mm. Chestnut to violet brown above, strongly iridescent; paler, brownish yellow below. Body cylindrical, posterior slightly depressed. Prostomium tanylobous. First dorsal pore 6/7. Spermathecal pores in 9/10/11 immediately almost in c lines. Clitellum saddle-shaped 27,28-33,34. Tubercula pubertatis narrow bands on 28,29-32,33(34) lateral to b lines; tumescences (pale) around ab usually only on 10 or 9 and 10. Setae closely paired. Male pores small lateral of b setae on 15 superficial or on slight tumescences.

Distribution: Palaearctic (excluding Iberian peninsula), from Siberia (Boganida River?) to Scandinavia, Faeroes, Iceland and North America [e.g. New Brunswick, Newfoundland, Nova Scotia, Ontario, Quebec, Delaware, Connecticut, Idaho, Maine, Maryland, Massachusetts, New York, Oregon, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, Washington and Alaska], spreading throughout Nearctic [e.g. Mexico (Gates, 1972) and Bermudas (Stöp-Bowitz, 1969: 241)]. Himachal Pradesh, India (Julka, 1980). South Africa, at Benvie Farm garden, Karkloof (KZN), where it was found with the introduced lumbricids *A. eiseni, D. rubidus, L. rubellus* and *Octolasion lacteum* and with an endemic microchaetid (Plisko, 1997). In British Isles found in almost every county, plus on Isle of Man, Isle of May and Channel Isles. Introduced to Southern Hemisphere in St Helena and New Zealand (Lee, 1959); and now Australia: in SA, NSW, Tas. (new records).

Locality: SA (J. Buckerfield pers. comm, and pers. obs.); Budderoo, NSW; Tasmania, (pers. obs.) specimens are lodged in QVM collection – new records Australia.

Habitat: decaying leaves, manure, soils with high organic content (pH 3.9-8.4), taiga, steppes, under logs and stones, river banks, caves, gardens, pasture and arable land. Reported by Gates (1972: 115) on exposed ridges with snow 1m deep and frost to 18 cm below (specimens that had copulated). Not found deep in the earth.

Behaviour: Obligatory amphimictic; copulates below ground but wanders on surface at night. When disturbed, the worm withdraws backwards, flattens and contracts so that the clitellum appears to be in mid-body.

Length: 30-70 mm.

Width: 2-4 mm.

Segments: 72-100. Body cylindrical, slightly depressed posteriorly.

Colour: Chestnut to violet brown above, strongly iridescent; paler, brownish yellow below; clitellum orangy.

Prostomium: Tanylobous.

First dorsal pore: 6/7 (or between 5/6-8/9).

Setae (ratio of aa:ab:bc:cd:dd:U): Delicate, 8 per segment closely paired; (5:1:5:1:20:0.5); ventral setae of 10 in conjoined tumescence (sometimes on 9 or 11 instead); setae a (and b?) sometimes marked on 28 and 33.

Nephropores: Alternate irregularly on each side of body above b and d lines.

Clitellum: Saddle-shaped 27,28-33,34 (usually 28-33).

Male pores: Small lateral of b setae on 15 superficial or on slight tumescences.

Female pores: Lateral to b in 14.

Spermathecal pores: Small paired in 9/10/11 in cd but almost in c lines.

Genital markings: Narrow bands on 28,29-32 lateral to b lines; tumescences around ab in 9-14 but usually only on 10 or 9 and 10 – paler and connected ventrally; also some of 24-33.

Septa: Not noticeably muscular.

Hearts: (7-11).

Gizzard: (17).

Calciferous glands: Calciferous sacs opening posteriorly into the oesophagus of segment 10 ventrally and just in front of septum 10/11. Calciferous lamellae continued along lateral walls of the sacs.

Intestine origin (caeca, typhlosole): 17+; typhlosole from region of 21/22.

Nephridia: Holoic, bladders J-shaped.

Male organs: Testes/funnels holandric; seminal vesicles paired in 9, 11 and 12, the latter pair may extend to 13.

Ovaries: In 13.

Prostates: None.

Spermathecae: Two small pairs with short ducts in 9/10 and 10/11; sometimes an extra pair in segment 8.

Gut contents: ?

Notes: "*A favourite bait for the river trout*" (Johnston, 1865: 59).

Chromosome number 2n = 36 (Gerard, 1964: 46).

Gates (1949) noted 'head' regeneration back from 6/7.

Remarks: *L castaneus* is similar, and may easily be confused with *L. rubellus* by

superficial glance, Gates (1972: 115) wondered how closely related they both are. Furthermore, he states that unless interbreeding is possible, ***L. disjunctus*** Tétry, 1936 may have separate specific status with these characteristics: size 50-82 by 4.5-5.5 mm, segments 93-111, tubercula pubertatis bilobed ventrally because of widenings in region of 29/30 and 31/32, genital tumescences in 8-13 but rarely in 10. Genetics will decide.

Lumbricus festivus (Savigny, 1826)

Fig. *L. festivus* from Sims & Gerard (1999 fig. 34).

Enterion festivum Savigny, 1826: 180. [Type locality Paris. Types in Paris Museum].

Lumbricus omilurus Templeton, 1836: 235. [Ireland. Types missing]; Johnston, 1865: 63 (syn. *rubsecens*), "*Common in rich grounds generally where docks grow*" – Templeton.

Omilurus rubescens Templeton, 1836: 235. [Ireland. Types?].

Lumbricus rubescens: Friend, 1891: 273 [referreing to Templeton's taxon].

Lumbricus festivus: Dugès, 1837: 17; Michaelsen, 1900: 512 [syn. *L. omilurus*, *Omilurus rubescens* (J. Templeton in MS) R. Templeton); Smith, 1917: 180; Tétry, 1937: 153; Gerard, 1964: 46; Stöp-Bowitz, 1969: 246, fig. 59; Reynolds, 1977: 92, fig. 30 (syn. *omilurus*, *rubescens*); Easton, 1983: 482 (syn. *omilurus*, *rubescens*); Sims & Gerard, 1985, 1999: 100, fig. 34; Blakemore, 2004; 2006; 2007.

Taxonomic Note: Easton (1983: 482) mistakenly lists *Omilurus omilurus* Templeton, 1836 as type and *L. rubescens* Friend, 1891 in synonymy, but Reynolds & Cook (1976) list *Omilurus* (type *O. rubescens* Temp.) gen. dub., *L. omilurus* Templeton, 1836 and *O. rubescens* Templeton, 1836. While Michaelsen (1900: 508, 512) actually has "*Omilurus* (type *O. rubescens*) (J. Templeton in MS), R. Templeton" in synonymy of *Lumbricus* and "*L. omilurus*, *Omilurus rubescens* (J. Templeton in MS), R. Templeton" in synonymy of *L. festivus*. The taxonomist mentioned is Robert Templeton.

Diagnosis: Length 48-110 mm. Segments 100-120. Chestnut to violet brown above, paler below. Body cylindrical, posterior slightly depressed. Prostomium tanylobous. First dorsal pore 5/6/7. Setae closely paired. Spermathecal pores in 9/10/11 in cd lines. Clitellum saddle-shaped 33,34-39,40. Tubercula pubertatis narrow bands on 35-38 lateral to b lines; tumescences around ab on many of 8-14, 18, 25-27 and around clitellar

region. Setae closely paired. Male pores lateral of b setae on 15 on largish tumescences that encroach on adjacent segments.

Distribution: Western Europe, Sweden, Denmark, Germany, Belgium, northern France; British Isles [England, Wales and Ireland, Channel Islands (Guernsey), rarer in Scotland but found in Outer Hebrides); Canada (New Brunswick, Quebec, Nova Scotia, Ontario and British Colombia); USA (Vermont); "?Australia" (Gerard, 1964: 47; Stöp-Bowitz, 1969: 248) - but I can find no corroboration of these Australian records.

Locality: Collected by RJB at Y Plas Machynlleth, 22nd VI 2013 (specimen in NHM).

Habitat: Pasture, damp often acid soils, river banks, in soil beneath manure or leaves, and under stones.

Behaviour: ?

Length: 48-155 mm. **Width:** 3.5-6 mm.

Segments: 100-143. Body cylindrical, slightly depressed posteriorly.

Colour: Dark, chestnut to violet brown with iridesence above, paler below.

Prostomium: Tanylobous.

First dorsal pore: 5/6.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired; (5:1:4:1:18:?); setae ab characteristically diverging from 2-5 then converging from 5-10 (Stöp-Bowitz, 1969: 247).

Nephropores: Alternate irrecularly on each side of body above b and d lines.

Clitellum: Saddle-shaped 33,34-39,40.

Male pores: Small lateral of b setae on 15 on slight tumescences that encroach on adjacent segments.

Female pores: Lateral to b in 14.

Spermathecal pores: Small paired in 9/10/11 in cd lines.

Genital markings: Tubercula pubertatis narrow bands on 35-38 lateral to b lines; tumescences around ab on many of 8-14, 18, 25-27 and around clitellar region.

Septa: Anterior septa thin and those in 9/10/11 delicate and adpressed.

Hearts: (7-11).

Gizzard: (17).

Calciferous glands : Calciferous sacs opening posteriorly into the oesophagus of segment 10 ventrally and just in front of septum 10/11. Calciferous lamellae continued along lateral walls of the sacs.

Intestine origin (caeca, typhlosole): (>17; typhlosole?).

Nephridia: Holoic, bladders J-shaped.

Male organs: Testes/funnels holandric; seminal vesicles paired in 9, 11 and 12, the latter pair may extend further back.

Ovaries: In 13.

Prostates: None.

Spermathecae: Two pairs in 9 and 10.

Gut contents: ?

Notes: Chromosome number 2n = 36 (Gerard, 1964:46). Just as *L. castaneus* is similar to *L. rubellus* so is *L festivus* comparable to *L. friendi* Cognetti, 1904. This latter species is generally larger and more rare, separated mainly on slight segmental shifting of clitellum and tubercula pubertatis, as noted below.

Lumbricus friendi friendi Cognetti, 1904

Fig. *L. friendi* from Friend's original drawing.

Fig. *L. friendi* from Sims & Gerard (1999 fig. 35).

Lumbricus papillosus Friend, 1893: 453, figs. 1-5 (non Müller, 1776). [Type locality Leeston Park House in Dublin, also from Glasnevin, Cork and Valencia Island in Kerry, Ireland. Types missing (from Oxford?) but Dublin topotypes rediscovered by Boots *et al*., 2012 (*Biodiversity*, **10**: 8-9)]; Michaelsen, 1900: 512.

Dendrobaena lumbricoides Bretscher, 1901: 219. [Types in Zurich].

Lumbricus friendi Cognetti, 1904: 10 [nom. nov. pro *Lumbricus papillosus* Friend, 1893 non Müller, 1776 (= *Arenicola marina* (Linnaeus, 1758) – Polychaeta)]; Gerard, 1964: 47; Easton, 1983: 482 (syn. *lumbricoides*); Sims & Gerard, 1985: 102, fig. 35; Csuzdi & Szlavecz, 2003; Blakemore, 2005, 2006, 2007, 2008, 2010.

Notes: a subspecies is ***L. friendi bouchei*** Zicsi & Csuzdi, 1999: 988 from France [replacement name for "*L. friendi* var. *lineatus* Bouché, 1972: 357" (non Müller, 1774 Tubificidae) that has types in France; as discussed by Blakemore, 2005, 2006, 2007, 2008, 2010).

Diagnosis: Length 45-200 mm. Chestnut red or brownish red above, paler below. Body cylindrical, posterior slightly depressed. Prostomium tanylobous. First dorsal pore 6/7-

9/10. Spermathecal pores in 9/10/11 in d lines. Clitellum saddle-shaped ½32,33-37,½38. Tubercula pubertatis slender ridge on 34-36 or 34-37 in bc lines, papillate in 34 and 36; tumescences around ab on 9-11 and 28,29-39,40. Setae closely paired. Male pores ventral of c setae mostly confined to 15 but slight encroachment on adjacent segments.

Distribution: Austria, Switzerland (Wallis), France, Spain, Andorra, Channel Isles (Jersey), Wales (Bangor), and Ireland (e.g. Dublin, Glasnevin, Cork, Valencia or Valentia Island, Kerry, and Johnstown); rare in Western Europe but said to be common in Uruguay (Gates, 1972: 113) (possibly introduced from Spain?); recently collected from Germany (Lamparski, 1985), Scotland (Boag *et al.* 1997), Baltimore/Washington metropolitan area in USA North America (Csuzdi & Szlavecz, 2003); also known from a forest site in Morocco (Omodeo *et al.*, 2003).

Locality: Not found in current study.

Habitat: Under forest litter but also from pastures, arable soils and moist gardens, in both sandy and calcareous soils pH 4.0-8.0.

Behaviour: Described as a "*large bodied anecic*" (by Csuzdi & Szlavecz, 2003).

Length: 45-200 mm.

Width: 4-8 mm.

Segments: 70-130. Body cylindrical, slightly depressed posteriorly.

Colour: Red or brownish red above, paler whitish below.

Prostomium: Tanylobous.

First dorsal pore: 6/7-9/10, small.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired; (ca. 8:1:7:1:24).

Nephropores: Alternate irregularly on each side of body above b and d lines.

Clitellum: Saddle-shaped ½32,33-37,½38.

Male pores: Small median of c setae on 15 on slight tumescences that just encroach on adjacent segments.

Female pores: Lateral to b in 14.

Spermathecal pores: Small paired in 9/10/11 in d lines.

Genital markings: Tubercula pubertatis slender ridge on 34-36 or just into 37 in bc lines, papillate in 34 and 36; tumescences around ab on 9-11 and 28,29-39,40.

Septa: Anterior septa not obviously thickened.

Hearts: (7-11).

Gizzard: (17).

Calciferous glands: Calciferous sacs opening posteriorly into the oesophagus of

segment 10 ventrally and just in front of septum 10/11. Calciferous lamellae continued along lateral walls of the sacs.

Intestine origin (caeca, typhlosole): (17; typhlosole?).

Nephridia: Holoic, bladders J-shaped.

Male organs: Testes/funnels holandric; seminal vesicles paired in 9, 11 and 12, the latter pair may extend further back.

Ovaries: In 13.

Prostates: None.

Spermathecae: Two pairs.

Gut contents: ?

Notes: Obligatory biparental. Chromosome number 2n = 36 (Gerard, 1964:47). The species is comparable to the smaller *L castaneus* but they rarely occur together and is especially similar to *L. terrestris* (see comparions in Csuzdi & Szlavecz, 2003). It is found to be anecic and to dominate a no-till system in the USA, (positively) affecting sorptivity and runoff in these systems (Szlavecz, 2008) and to be abundant in the Schwartzwald (Black Forest) region of Germany where its ecology is summarized by Lamparski (1985), who rather surprisingly finds the specimens smaller than anecic congeners, as:

> "*The atlantic species* L. friendi *must be considered as the direct ancestor of* L. badensis*. In the foothills of Weitenau and on the southern border of the Black Forest both species are found together in the same biotope but without bastardization. The difference in size seems to be a sufficient isolating mechanism: In the investigations area* L. friendi *achieves a fresh weight of 4g,* L. badensis *ranges from 25g to 40g fresh weight*."

Lumbricus rubellus Hoffmeister, 1843

Fig. 6.20 *Lumbricus rubellus* Scullin specimen (a) ventral view (b) tanylobous prostomium.

Fig. 6.20a Distinctive cocoon of *L. rubellus* from Beddard (1896: fig. 194).

Lumbricus rubellus Hoffmeister, 1843: 187, fig. II. [Type locality and types unknown].

Lumbricus campestris (part) Hutton, 1876/7: 351. [Locality Wellington, New Zealand; see Benham, 1898 when type material was in the Otago Museum A56.20].

Enterion rubellum var. *parvum* + var *magnum* Örley, 1881: 588, 589. [Types?].

Digaster campestris (part): Hutton, 1883: 586.

Lumbricus rubellus var. *curticaudatus* Friend, 1892: 312. [Types?].

Allolobophora rubellus (sic): Smith, 1894: 117.

Lumbricus rubellus tatrensis Nusban, 1895. [Types?].

Allolobophora herculeana Brescher, 1899: 419. [Types in Zurich].

Allolobophora ribaucourti Brescher, 1901: 220. [Type in Zurich]. [Non *Helodrilus ribaucourti* Cognetti, 1901 (= *Dendrobaena cognetti* = *D. pygmaea*)].

Allolobophora relictus Southern, 1909: 169. [From Clare Island, Co. Mayo. Type, an abnormal specimen of *L. rubellus* according to Gerard (1964: 51), lost].

Lumbricus rubellus tristani Pickford, 1932: 289. [From Tristan da Cunha. Types in US Natl. Museum and in BMNH].

Lumbricus rubellus rubellus + *L. r. castaneoides* + *L. r. friendoides* Bouché, 1972: 368,371,372. [Types in France].

Lumbricus rubellus: Stephenson, 1923; Gerard, 1964:47; Gates, 1972: 78 (syn. *relictus*); Reynolds, 1977: 94, fig. 32 (syn. *castaneoides* + *friendoides*); Sims & Gerard, 1985: 104, fig. 36; Blakemore, 1999: 183; Csuzdi & Zicsi, 2003 (syns. incl *castaneoides* + *friendoides*).

Lumbricus rubellus rubellus: Easton, 1983: 482 (syn. *campestris*, *rubellus curticaudatus*, *rubellus tatrensis*, *herculeana*, *ribaucourti*, *relictus*, *rubellus tristani*); Blakemore, 2004; 2006; 2007 (syns. as above).

Taxonomic Note: Easton (1983: 482) accepted subspecific status for Bouché's taxa (***castaneoides*** + ***friendoides***), unlike Reynolds (1977) and Csuzdi & Zicsi (2003) who list both as synonyms; Blakemore (2007, 2008) allowed that they may be synonymous.

L. rubellus is rarely confused with other species due to its relatively consistent characters, habits and habitats – except by worm-growers and their ilk who I have also seen misspel it as "L. rebellus" (cf. "L. terrorist"?).

Diagnosis: Length 60-150 mm. Chestnut to violet brown above, paler below. Body cylindrical, posterior slightly depressed. Prostomium tanylobous. First dorsal pore 5/6-8/9. Spermathecal pores in 9/10/11 in c lines. Clitellum saddle-shaped 26,27-32. Tubercula pubertatis narrow bands on 27,28-31,32 lateral to b lines; tumescences around ab in some or all of 10-12, 22 and around clitellar region. Setae closely paired. Male pores between bc superficial on 15.

Distribution: Holarctic. Greenland, Iceland, Scandinavia, Siberia, Russia from White Sea through to Crimea and Pri-Urals, western Europe and most of British Isles, Madeira,

Canary Islands, Tristan da Cunha; Iran; Afghanistan; Canada; USA (Juneau, Alaska, and most mainland states); Bogota, Colombia (Feijoo *et al*., 2004); Isla Chiloe - the variety of potatoe which is most widely grown throughout the world is indigenous to the island - Chile (Zicsi & Csuzdi, 2001); also Bolivia, Mexico and Argentina (Brown & Fragoso, 2007); peninsular India (and Nicobar Islands); South Africa; and widespread and common in N.Z. and on Chatham and Kermadecs (Lee, 1959) and Australia:- found in ACT; at Churchill, Vict.; Budderoo, NSW; and many locations in Tasmania. For early Australian reports see Fletcher (1886-1890).

Locality: Obtained from gardens at Scullin and Kippax, ACT; under pasture and in garden soils in NSW and Tasmania. Collected by RJB at Y Plas Machynlleth, 22nd VI 2013 (specimen in NHM).

Habitat: Mostly in areas with high organic matter, from peat bogs to pastures, cultivated lands and garden soils; commonly aggregated under dung pats in pastures and under stones or planks (possibly for higher moisture access but may also relate to funal or microbial food supply). Has wide environmental tolerances for soil pH and temperature eg optimal is 18º C but a specimen was recovered alive from natural ice (Gates, 1972: 117). Reported in "tremendous concentation" in sewage beds (but possibly = *E. fetida*).

Behaviour: Body and tail flatten when disturbed and it wriggles back and forth.

Length: (25) 60-150 mm.

Width: 3-6 mm.

Segments: 70-126, body circular, tail distinctively flattens and becomes spade-shaped.

Colour: Dorsum red-brown, ventrum pale, clitellum buff.

Prostomium: Tanylobous.

First dorsal pore: Apparently variable, 5/6/7/8/9.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment closely paired from 2, wider on anterior (ventral setae on 10 reduced or dehisced); (5:1:5:1:20:0.4).

Nephropores: In d setal lines or just dorsal, or alternating irregularly with bc setal lines.

Clitellum: Saddle-shaped, ½26,27-31,32, slightly flared out (as in *A. rosea*).

Male pores: Small equatorial slits, almost lateral and confined to 15 superficial or within slight tumid lips.

Female pores: Minute, just lateral to b in 14.

Spermathecal pores: In 9/10/11 in c lines

Genital markings: Tubercula pubertatis as translucent ridges lateral to b lines, in 27-31; ventral setae on some of 10-12 and 22-26 in slight tumescences.

Septa: 7/8/9 slightly thickened, none especially thick.

Hearts: 7-11.

Gizzard: 17.

Calciferous glands : Calciferous sacs opening posteriorly into the oesophagus of segment 10 ventrally and just in front of septum 10/11. Calciferous lamellae continued along lateral walls of the sacs.

Intestine origin (caeca, typhlosole): 17; typhlosole beginning from about 21,22.

Nephridia: Holoic, bladders J-shaped.

Male organs: Testes/funnels holandric; seminal vesicles paired in 9, 11 and 12, the latter pair may extend further back.

Ovaries: In 13.

Prostates: None.

Spermathecae: Two pairs.

Gut contents: ?

Notes: Obligatory biparental copulation, like casting, is believed to be below ground although this species is also considered a superficial or litter dweller. Chromosome number 2n = 36 (Gerard, 1964: 47). Food passes through gut in 16-48 hours and it is regarded, like *D. octaedra*, as an important converter of leaf litter.

Claims for cultivation by worm-growers as "*Red worms*" or some-such have, on inspection, invariably been *Eisenia fetida*; so much so that my last colleague John Buckerfield of Adelaide offered to eat any that were actually proven to be *L. rubellus* [cf. Gates (1972: 118) who says it is cultured in a number of US states and that it is widely sold and used for fishing bait – perhaps he meant that these were claimed from there].

Lumbricus terrestris herculeus (Savigny, 1826) stat. nov.

Enterion herculeum Savigny, 1826: 180. [Type locality Paris, lectotypeMNHN].

Lumbricus herculeus: Dugès, 1837: 17,21; Tètry, 1937: 151 (180?); Michaelsen, 1899: 249; Bouchè, 1972: 352; James *et al*. 2010 restoration (but see Blakemore, 2013).

Lumbricus terrestris (part?): Michaelsen, 1900: 511.

Diagnosis: Same as *Lumbricus terrestris* as described below.

Distribution: Europe, reported from Kew Gardens (Beddard, 1906) and by Garman (1888: 73) who noted that Eisen found it in New England – thus a possible valid

record for USA as an introduction, although these may be misidentifications for *L. terrestris*.

Remarks: Claimed as a "cryptic species" indistinguishable morphologically from *L. terrestris* with which it has usually been combined, James *et al*. (2010) provide DNA data supposed to be sufficient for differentiation. Although other synonyms were not checked neither were any behavioural differences noted. They also stated "*L. herculeus has yet to be found outside of Europe*" but seem to have overlooked the earlier USA references noted above. Their re-neotypification of *L. terrestris* was nullified (Blakemore, 2012, 2013).

Since it is obviously allied to *L. terrestris* perhaps differing only is a slightly smaller size, it only merits sub-specific status as *L. terrestris herculeus* (stat. nov. 2018).

Lumbricus terrestris terrestris Linnaeus, 1758 stat. nov.

Fig. 6.21. *Lumbricus terrestris* Invermay specimen, the first from Australia (Tasmania). See also figures in Blakemore (2012, 2013) of neotype specimen.

Annotated synomomy:

Lumbricus terrestris (part) Linnaeus, 1758: 647. [Type locality Sweden. Neotype in British Museum (Sims, 1973) – BMNH 1973:1:1 falsely claimed as misplaced, with a new neotype designated by James *et al.*, 2010 that now (Blakemore, 2013) loses its status and the original neotype yet stands, unless any syntypes appear]. [Note: Original spelling was as "*L. terreſtris*" in older style long-s typography, where a non-terminal 's' looked like an 'f'. Linnaeus included in its early synonymy *Lumbricus laevis, L. terrestris minor, L. terrestris minor rubicundus, L. major, L. intestinorum teres* and *Lumbricus humanus* Vallisneri, the latter being the intestinal nematode worm - *Ascaris lumbricoides* (Linnaeus, 1758)].

Lumbricus terrestris (part.) : Linnaeus, 1766: 1076. [First revisior status].

Lumbricus terrestris (part.): Müller, 1774: 24.

Lvmbricvs terrestris (sic) : Fabricius, 1780: 276-277. [Where Latin "v" replaces "u"].

Lvmbricvs norvegicus (part.) : Fabricius, 1780: 277 (for *A. norvegica* Eisen, 1874: 48?).

[?Non *Enterion terrestre* Savigny, 1822: 103 – *sp. dub.* sometimes misdated "1820". Egyptian].

Lumbricus terrester (part.) : Blumenbach, 1825: 265.

Enterion herculeum Savigny, 1826: 180. [From Paris. Type in Paris claimed by James *et al.*, 2010 to be a "*cryptic species*" of *L. terrestris* but other synonyms, as provided by Sims (1973: 28), not checked; note this species already maintained in *Lumbricus* by Michaelsen (1899: 249) and by Garman (1888: 73) who says Eisen found it in New England, USA but these maybe misidentifications for *L. terrestris*].

Lumbricus herculeus: Dugès, 1837: 17, 21; Tètry, 1937: 151 (180 mistake? See Sims, 1973: 29); Michaelsen, 1899: 249; Bouchè, 1970: 541, 1972: 352 (misapplications of names); James *et al*. 2010 attempted restoration (but see Blakemore, 2013).

[Non *Lumbricus terrestris*: Dugès, 1837: 17,18 (misid. of *A. longa* (Ude)].

Lumbricus agricola Hoffmeister, 1842: 24, figs. 11-14, 17. [From neighborhood of Berlin. Types lost].

Lumbricus infelix Kinberg, 1867: 98. [From Port Natal. Type Stockholm, 1930].

Lumbricus americanus Perrier, 1872: 44. [Type in Paris].

Lumbricus studeri Ribaucourt, 1896: 5. [Types?].

Lumbricus terrestris : Johnston, 1865: 58; Michaelsen, 1900: 511 (syn. *herculeum*, *agricola*, *infelix*, *americanus*, *studeri*); Graff, 1953: 324; Gerard, 1964: 48; Stöp-Bowitz, 1969: 242; Gates, 1967; 1972: 118; Sims, 1973: 27, 32; Easton, 1983: 482; Sims & Gerard, 1985; 1999: 106, figs. 1, 4, 6, 9j, 37, 38; Blakemore, 1997; 2002; 2005; 2006; 2007; 2010; 2012 (syns. as above); Csuzdi & Zicsi, 2003: 188. [Non Tetry (1937: 151), nec Bouché (1970: 541), nec James *et al.* (2010)? – see Sims, 1983; Blakemore, 2013].

Lumbricus terrestris terrestris (part.) : Qiu & Bouche, 1998: 192. [Name just listed, no other sub-species listed, thus probable miscitation. However sub-specificity should perhaps be here restated as stat. nov. to differentiate between this and the possibility, yet to be determined, of establishment of subspecies such as, *L. terrestris herculeus*].

Note: Name sometimes mispelt *Lumbricus* "terroristis", as with *Lumbricus* "rebellus"

Diagnosis: Length 90-350 mm. Chestnut to violet brown above, paler below. Body cylindrical, posterior characteristically depressed and spade-shaped. Prostomium tanylobous. First dorsal pore 7/8/9. Spermathecal pores in 9/10/11 in cd lines. Clitellum saddle-shaped 32-37,38. Tubercula pubertates longitudinal ridges on 32,33-

36,37 lateral to b lines; tumescences around ab in some or all of 8-14, 24-29 and around clitellar region. Setae closely paired. Male pores lateral to b lines on 15 in prominent lips commonly impinging onto adjacent segments and with seminal grooves to clitellum.

Distribution: Holarctic: Greenland, Iceland, Scandinavia, Siberia, Russia, western Europe and British Isles including Isle of Man and Jersey, to the northeast of Iberian peninsula (afterwhich it is largely replaced in the Iberian peninsula by *L. friendi* according to Monroy *et al.*, 2003). Introduced to Azores, Madeira, USA (widespread but sometimes deliberately transported for fishing bait as noted by Gates, 1972: 120), Canada (e.g. Alberta, British Columbia, New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, and Quebec although a report from Saskatoon, Saskatchewan is a mis-identification); temperate regions of Central and South America (e.g. Falklands by Stöp-Bowtiz, 1969 and by Zicsi, 1993; Chile by Zicsi, 2004; Mexico by Gates, 1942: 104; and Uruguay by Gates, 1972: 119 and Christoffersen, 2011: 159); India (and western Himalayas); South Africa [at least by deliberate importation for study and Kinberg's *infelix* although Michaelsen (1899: 421) doubted its earlier records from "Pt Natal" and it has never been re-confirmed, thus Gates' (1972: 119) report is possibly incorrect]; N.Z. (Lee, 1959), Tasmania – a new Australian record by current author. A previous report from "*Australia*" is uncorroborated and false (for details see Blakemore, 1997c; 2002, 2012). In December, 2021 this author (RJB) identified specimens from Japan (possibly from stocks in Hokkaido although the company "Marunichi Co., Ltd" is based in Ehime ken, Shikoku) being sold all over the country as fishing bait called "Ozeki" – **this is a new record for Japan and East Asia**.

Note: James *et al.* (2010) when attempting to restore the synonym also state "*L. herculeus* has yet to be found outside of Europe" but seem to have overlooked the earlier USA references noted in synonymy as already noted above.

Material examined: NHM London neotype, a mature specimen previously dissected dorsally with cuticle partly removed, in jar with three labels: "*Lumbricus terrestris* L. 1758 Neotype. Uppsala. 1973.1.1."; "*Lumbricus terrestris* Linnaeus 1758 TYPE Loc. Uppsala"; "Lumbricus terrestris *Linnaeus no longer contains NEOTYPE 1973.1.1 Loc: Uppsala. Note: Originally this number was designated for the L. terrestris neotype determined by R.W. Sims in 1973. Following examination by V. Pop (visiting at NHM, 2009) and S. James (James et al. PLOS ONE Dec 2010, vs, issue 12e15629) it was discovered that this jar no longer contains Sims' described neotype, which must now be considered missing*.". Plus one label I added restoring its status as Neotype in 2013 (see

Blakemore, 2013: fig. 1). Sims (1973: 32) gives details as collected from lawn close to the Botanical Garden, Uppsala, Sweden; 13th Oct. 1972, collectors B. Axelsson, U. Lohm and T. Persson (preserved in formalin and 80% alcohol).

Locality of other specimens: Found by the author in supposedly 1,000 yr old paddock and organic field at Haughley farm in 1980 (Blakemore, 2000). Numerous 'middens' seen at organic orchards at UC Davis, California in 2000 (also R.L. Bugg pers. comm. and pers. obs.). Launceston, north Tasmania; escaping over soil surface of suburban garden when digging drains to 1 m depth in black clay at 145 Holbrook St., Invermay; R.J. Blakemore, 29th June, 1997 (mature, complete specimen; fixed in 10% formalin, preserved in 80% ethanol in QVM collection). Recently found by author at Mt Wellington, Auckland in paddock soil (Blakemore, 2012); specimen in Auckland Museum (AMNZ 5265); also collected by RJB at Y Plas Machynlleth, Wales on 22nd VI 2013 (large specimen released in NHM gardens with help from Emma Sherlock). Two specimens of the 2021 "Ozeki" bait worms from Japan deposited in Odawara Museum (fixed and preserved in 70% EtOH to facilitate future DNA extractions and analyses).

Habitat: Mull soils, fields, pastures orchards and deciduous forests, mud flats, manure heaps, taiga, forests and steppes, common in grasslands (avoids pine/beech forests?). In alkaline soils of pH 6.2-10.0; especially abundant in clay. Sometimes caves, often in golf courses. Stöp-Bowitz (1969: 246) found a specimen on snow in December although he thought it forms deeper burrows to 7-8 feet (>2m) in winter.

Behaviour: Nocturnal copulating and feeding on surface; posterior third assumes flattened spade-like shape when agitated and worms retreat backwards. Maintains permanent burrow systems and forms 'middens' around entrances which may be clogged with leaves, feathers or other debris. Classed as "*anecique*" by Bouché and only this part of Bouche's ecological terms accepted by Blakemore (2005) as "anecic".

Body length: Anterior circular, posterior often dorso-ventrally flattened; 90-350 mm (neotype 155 mm but coiled and twisted; cf. 165 mm Sims, 1973).

Width: 6-12 mm (neotype ca. 7-9 mm maximum).

Segments: Ca. 120-155 [neotype ~151 but with secondary schizo-metameres, see Blakemore (2013: fig. 2), cf. Sims (1973) 153 segments].

Colour: Anterior dorsum deep ruddy brown to gunmetal grey to d setal lines with blue iridescence, retained as dark mid-dorsal line to posterior; ventrum pale (pink in life); clitellum orangy buff (yellowy in life); preserved specimens uniform buff.

Prostomium: Tanylobous.

Clitellum: ½31,32-37,38 saddle-shaped mostly to bb lines (neotype ½31,32-37).

Dorsal pores: 7/8 small, from 8/9 larger.

Setae (ratio aa:ab:bc:cd:dd:C): 8 per segment, closely paired in regular rows; ca. 6:1:5:1:22:0.5C, cf. 5:1.5:4:1:0.5C or 4:1.3:2.1 in neotype (Sims, 1973: 32).

Nephropores: Large at anterior margin of segment just lateral level of b setal lines on many segments (e.g. on right-hand side on 11-15, 20, 22-25, 28, 30-36, 39-44, etc.), irregularly alternating to between d and mid-dorsum (e.g. on rhs seen in dorsal position on 3-7, 9, 17-19, 21, 26-27, 29, 33-34, 37-39, 44-45); in some segments the pores appear to be in both positions on one side but reasons for this are unknown.

Spermathecal pores: In 9/10/11 in cd nearer to c lines; [Sims (1973: 32) says inconspicuous in b lines but I could not locate them there in the dissected neotype].

Female pores: Paired just lateral of b setae on 14.

Male pores: Towards lateral extremity of equatorial slits within tumid lips between a and c setal lines confined to 15; distinct mound tract (formed by parallel seminal duct grooves) extends from male pores to clitellum between bc lines on both sides.

Genital markings: Tubercula pubertatis as elongate smooth pads just median of c lines in 33-36; ventral setal couples within slightly tumid pads, especially 8,9-11, 25, 26, and 31,32 often to 37,38; Sims (1973: 32) has ab tumid on 25 and 26 as reconfirmed here. These markings are orange-yellowish colour in life.

Septa: 6/7/8/9 thickened; or none especially muscular.

Hearts: Paired in 7-11.

Gizzard: Muscular in 17-19.

Calciferous glands: Calciferous sacs opening posteriorly into the oesophagus of segment 10 ventrally and just in front of septum 10/11. Calciferous lamellae continued along lateral walls of the sacs in 11-12.

Intestine origin (caeca, typhlosole): In 14, swelling in 15-16 to form crop; caeca absent; typhlosole mid-dorsal beginning from about 21-23.

Nephridia: Holoic, bladders J-shaped.

Male organs: Testes/funnels holandric testis in sacs in 10 & 11; seminal vesicles paired in 9, 11 and 12, the latter pair may also fill 13.

Ovaries: Small, paired in 13.

Prostates: None.

Spermathecae: Two pairs in 9 & 10 as small globular sacs dorso-ventrally placed.

Gut contents: Depends on habitat and diet.

Cocoons: Ca. 4x7mm diameter but elongate (Sims & Gerard, 1999: fig. 38b).

Ecology, life-cycle, symbionts and parasites: Provided by Gates (1972), etc.

Notes: Many references note that other species have frequently been confused with *L. terrestris* in the past, possibly due partly to its inaccurate characterization in school texts as "*the common earthworm*" - an expression rejected for this species by, amongst others, Stephenson, (1930) in a preface to his great monograph. Gates (1972: 123) remarks that "*A belief that almost any earthworm is* Lumbricus terrestris *is not entirely restricted to high-school graduates who have had an elementary course in biology (cf. Stephenson, 1930: p. xi)*". Its mistaken reports from Australia were by a university professor and also by a senior zoology curator (of polychaetes!).

L. terrestris is probably one of the main species about which Darwin (1881) wrote (cf. *A. longa*). The characteristic spade-shaped tail is believed to enhance gripping of the burrow walls, as its foraging behaviour is to anchor the tail in the mouth of the burrow to drag leaves and twigs back down for feeding. The burrow may extend to 3 m depth, and the entrance is often indicated by a small midden of pebbles and twigs as well as a plug of leaves, feathers etc. (Darwin, 1881; Gates, 1972; Sims and Gerard, 1985). This worm is usually described as being nocturnally active (e.g. Linnaeus, 1758: 648, "*adscendit noctu*"), its above ground wandering and copulation earning it the common name in North America of the "*European Nightcrawler*" (or in French Canada, "*Ver nocture rampant*"). However, its dark pigmentation indicates a need for protection from at least crepuscular sunlight and/or camouflage from predators when wandering in rain. The escape response of this species is invoked by stimuli that possibly emulate predatory European moles (*Talpa* spp.) for which this species is a favourite food and is exploited by predatory birds like lapwings (*Vanellus* spp.) that mimic the vibrations by stamping on the soil surface (Darwin, 1881: 28).

Reynolds (1977: 7, 101) explains how *L. terrestris*, although routinely collected at night for fishing bait and study in North America, cannot be commercially cultured economically because of its long life cycle, low reproductive rate, and large spatial requirements, however Dr Kevin Butt in UK has had claimed some success (Butt, 1991; Butt *et al.*, 1992). It is not known if Japanese bait specimens are cultured or collected (or both?).

A species that has, until relatively recently, been continually confused with *L. terrestris* is *Aporrectodea longa* (Ude). Gates (1972: 76) stated that: "A. longa *is not*

*known to have been sold or used for bait in North America but the species may have occasionally been mistaken for [*L.*]* terrestris*, unless anglers are more careful than university professors*".

Gates made this remark due to the frequent confusion of other taxa with *L. terrestris* proper, especially in school and university classes where it is often the iconic test organism. However, in east Africa at least, *Polytoreutus huebneri* Michaelsen, 1913 that grows to 390mm has been used (Sims, 1982: 254, 255). Moreover, Blakemore (2012) suggested using *Anisochaeta macleayi* similarly in Australasia where it is widely distributed (in Australia and New Zealand), abundant and relatively resilient.

Genus ***Murchieona*** Gates, 1978

Murchieona Gates, 1978: 114.

Type-species: *Allolobophora minima* Muldal, 1952 [= *Bimastos muldali* Omodeo, 1956 nom. nov. pro *A. minima* Muldal, 1952 (non *A. minima* Rosa, 1884)].

Diagnosis: Calciferous sacs with two chambers opening vertically through a U-shaped orifice into the oesophagus anteriodorsally in segment 10. Calciferous gland not constricted intersegmentally. Nephridial vesicles present. Nephopores obvious (in single rank on each side of body). Pigment absent. Prostomium epilobous. Lumbricine, setae closely paired.

Distribution: Europe (locally in Italy, France Spain and UK), USA (by introduction?) and, now, New Zealand.

Remarks: A combination of amphimictic and parthenogenetic morphs, *M. muldali* had been regarded, e.g. by Easton (1983: 483) and Sims & Gerard (1985; 1999: 109), as a junior synonym of *M. minuscula* but was resurrected by Zicsi & Csuzdi (1999: 990) and by Csuzdi & Pavlicek (2002: 108) on the grounds of position of the clitellum (and distributions), thus:

Murchieona minuscula (Rosa, 1906). [Types?]. Clitellum 26-32, TP lacking. From Greece, Turkey, Croatia, Gomera (Canary Isls), Italy, claimed from Algeria by Baha (1997), plus reported from Ireland by Schmidt & Curry (2001) and (native or by introduction?) Israel (Csuzdi & Pavlicek, 2002).

Murchieona muldali (Omodeo, 1956). [Types in BMNH 1951:5:31:1-17]. [Nom. nov. pro *A. minima* Muldal, 1952 (non *A. minima* Rosa, 1884). Clitellum 27-33. From France, (Spain?), Portugal, England, USA (introduced e.g. IN, MI, TN), and

Auckland, NZ - **new record by RJB**.

For convenience, both descriptions are still combined in the following account.

Murchieona minuscula (Rosa, 1905) [inc. ***M. muldali*** (Omodeo, 1956)]

Fig. 6.21.1 NZ *Murchieona minuscula/muldali* morph; Fig. 6.21.2 world distribution. Cf. Fig. Sims & Gerard (1999: fig. 39).

Allolobophora minuscula Rosa, 1906: 38. [Type locality ?Italy. Types ?]; Gates, 1975: 7; Zicsi, 1981: 176. Types?

Allolobophora (*Bimastos*) *icenorum* Pickford, 1926: 97. [Type locality near a gate leading from Broad Fen Drove to the disused brickworks at Wicken, Cambridgeshire. Types in British Museum BMNH:1926.8.3.19]. [Miscited as "icanarum" in Reynolds & Cook (1976: 115)]

Allolobophora minima Muldal, 1952: 463. [Type locality Bayfordbury, Hertfordshire. Types in British Museum 1951:5:31:1-17]. (Non *minima* Rosa, 1884 = *Dendrobaena pygmaea*)

Bimastos muldali Omodeo, 1956: 179 (nom. nov. pro. *A. minima* Muldal, 1952 preocc.); [this new name is sometimes quoted as originally being in *Allolobophora*].

Allolobophora muldali: Murchie, 1959: 329, fig. 1; Bouché, 1972: 452.

Allolobophora icenorum + *muldali*: Gates, 1958b.

Bimastos icenorum + *muldali*: Gerard, 1964: 34.

Allolobophora muldali var. *pickfordi* Bouché, 1972: 453. [Five non-sexual morphs. Types in France. Note: under ICZN (1999) code, intrasubspecific and varietal names are illegitemate after 1961 thus the nomenclatural validity of this synonym is uncertain; moreover, even if it is parthenogenetic, a new name is not warranted].

Murchieona muldali (part): Gates, 1978: 114.

Murchieona minuscula: Easton, 1983: 483 [syn. *icenorum* Pickford, 1926; *Allolobophora minima* Muldal, 1952 (non Rosa, 1884 = *Dendrobaena pygmaea*); *muldali* Omodeo, 1956]; Sims & Gerard, 1985; 1999: 44, 109-110, fig. 39 (syn. *icenorum*, *minima*, *muldali*, *Allolobophora muldali* var. *pickfordi* Bouché, 1972); Csuzdi & Pavlicek, 2002: 108, figs. 1, 2; Csuzdi (website);

Blakemore, 2004; 2006; 2007 (syns. as above); 2010.

Aporrectodea muldali: Schwert, 1990: 353; Zicsi & Csuzdi, 1999: 990 [resurrection and generic placement unexplained].

Note: Sometimes called the "Glass Worm".

Diagnosis: Length 20-60 mm. Prostomium epilobous. First dorsal pore minute 11/12/13 (or 14/15 by Csuzdi). Spermathecal pores 9/10/11, frequently absent. Clitellum 25,26,27-31,32,33,34 (often 27-33). Tubercula pubertatis absent or slight: posteriorly in 28, 29, 30, and sometimes 31. Setae closely paired.

Distribution: Europe (locally in Italy, France, Spain, Portugal, UK and Ireland), Israel, and USA [Indiana, Michigan e.g. by Murchie (1955) and Tennessee, by introduction?]. Generally rare. British records from Sims & Gerard (1999) are Cambridgeshire (Wicken); Berkshire (Whytham Wood); County Durham; Hertfordshire (Bayfordbury); Nottingham; Surrey (Kew). The "*muldali*" morph a **new record Australasia from NZ.**

Locality: Specimens beside outlet stream at Domain Auckland (the original city water supply) collected 27.x.2011 by RJB on way to work at Museum nearby, (two matures AMNZ 5279) identifed, DNA taken, and deposited in the Auckland Museum same day.

Habitat: Heavy soils with high moisture in rotting vegetation, in pasture and woodland.

Behaviour: Passive and rather fragile (pers. obs.)

Length: 20-60 mm.

Width: 1-2 mm.

Segments: 84-106.

Colour: Lightly pigmented pink to red or spotted; clitellum transparent, becoming white prior to deposition. Tail may have yellow pigment (but cf. *D. rubidus*).

Prostomium: Epilobous.

First dorsal pore: Minute 11/12/13, the latter in current specimens, or (Csuzdi, 2002) 14/15.

Setae (ratio of aa:ab:bc:cd:dd:U): Closely paired; 8:1:5:1:22:0.5.

Nephropores: In single rank on each side of body (?always in current NZ specimens they seem to occur laterally and verntrally in some segments).

Clitellum: 25,26,27-31,32,33,34; in 27-33 in current specimens.

Male pores: In 15 on prominent papillae extending over 14 and 16 above setal b lines.

Female pores: On 14 above setae a.

Spermathecal pores: 9/10/11 near d lines, frequently absent (as in NZ specimens).

Genital markings: TP absent or slight marginal thickening in setal a lines posteriorly in

or on 28, 29, 30, and sometimes 31. Tumescences sometimes around ab on 9-11, 27-33.

Septa: 5/6-8/9 slightly thickened.

Dorsal blood vessel: Single.

Hearts: Last in 6-11 (but small commissurals in 12).

Gizzard: 16-17, or (Csuzdi, 2002) 17-18 with crop in 15-16; difficult to determine, but I thought it in 17-18 with crop in 16 but counted it one segment forward first time.

Calciferous glands: Calciferous sacs with two chambers opening vertically through a U-shaped orifice into the oesophagus anteriodorsally in segment 10; to me the annular glands seemed to occupy 11 and especially 12.

Intestine origin (caeca, typhlosole): (From 15 or 16?). Typhlosole present as large 'drip-shaped' ridge.

Nephridia: Holoic, bladders present and irregularly tube-shaped; or sausage shaped in present specimens with thin ducts extending further and looping back ventrally.

Male organs: Testes/funnels in 10 and 11; seminal vesicles absent or in 11 and 12; or in latter only in present specimen.

Ovaries: In 13; small?

Prostates: None.

Spermathecae: Two pairs or, as in present NZ specimens, absent.

Spermatophores: One to three found in current Auckland specimens on segments between 22-24; cf. "*copulation observed and spermatophores collected*" (Sims & Gerard, 1999).

Gut contents: Dark soil in NZ specimens.

Remarks: Poorly known species with some residual confusion over the correct name. It is superficially similar to *D. hortensis.* Non-sexual (parthenogenetic) morphs were described by Pickford (1926) and by Bouché (1972: 453). Gates (1975) proposed the genus *Murchieona* for *Bimastos muldali* Omodeo, 1956, a replacement name for the preoccupied *Allolobophora minima* Muldal, 1952 that was not then recognized as being conspecific with the parthenogenetic *icenorum* Pickford, 1926. Sims & Gerard (1985; 1999: 44) explain how Zicsi (1981), from examination of types, found all three names to be syonymous with *minuscula* Rosa, 1906. Thus *minuscula* became monotypic for *Murchieona* as listed by Easton (1983: 483), although these changes seem not to have been much noted. Recently, Csuzdi & Pavlíček (2002) gave new a new record (for Israel) and again separated *minuscula* and *muldali* on points noted in précis above. (Longitudinal muscles are said to be pinnate but I am unsure in which name this occurs).

DNA: – as with *D. attemsi*, apparently the first time for this species too from 2011.

>RJB05_Murchiona-muldali blast closest 84%
AACCTTATACTTTATTCTAGGTATTTGAGCAGGTATAGTAGGAGCCGGTATAAGCCTCCT
CATTCGAATTGAACTTAGGCAGCCGGGAGCATTCCTAGGAAGAGATCAACTCTATAATA
CAATCGTCACAGCCCATGCATTTGTAATAATTTTTTTCCTAGTTATACCAGTATTTATTGG
TGGTTTTGGAAACTGGTTACTTCCCCTCATACTAGGGGCACCAGATATGGCATTTCCAC
GACTAAATAACATAAGCTTTTGATTACTTCCACCCTCATTAATTTTATTAGTTTCTTCTGC
TGCAGTAGAGAAAGGAGCGGGAACTGGTTGAACTGTATACCCTCCCCTAGCAAGAAAT
CTAGCTCACGCGGGACCTTCTGTAGACTTGGCCATTTTTTCACTTCATTTAGCGGGGGC
ATCATCAATTCTGGGGGCCATCAACTTTATTACAACAGTAATTAATATACGATGAAGAGG
TTTACGACTAGAACGAATTCCCCTATTTGTATGAGCTGTTGTTATTACCGTTGTACTCTTA
CTTCTATCATTACCCGTACTTGCTGGAGCTATTACAATACTACTTACAGATCGAAACCTA
AATACATCCTTTTTCGACCCTGCTGGAGGAGGAGACCCTATTCTTTATCAACATCTATTC

Genus ***Octodrilus*** Omodeo, 1956

Octodrilus Omodeo, 1956: 177.

[Syns. *Octolasion* (*Purpureum*) Omodeo, 1952: 46 (type-species *Allolobophora lissaensis* Michaelsen, 1891)].

Type-species: *Lumbricus complanatus* Dugès, 1828 as per Sims (1984) and ICZN Opinion No. 1403 which suppressed the genus *Purpureum* and accepted *L. complanatus* as type of *Octolasium* (*Octodrilus*) Omodeo, 1956.

Taxonomic Note: Easton (1983: 483) lists 38 species, Blakemore (2005) 51 taxa, including the relatively large *Octodrilus frivaldszkyi* (Örley, 1885).

Diagnosis: Pigment red, brown, or weakly blue. Prostomium epilobous. Setae not closely paired. Spermathecae numerous (e.g. five to eight pairs). Tubercula pubertatis extends for most of length of clitellum and sometimes one or two segments beyond it. (Cf. *Octolasion*). Calciferous glands in 10-12 with lateral diverticula in 10. Nephridial bladders ocarina-shaped.

Distribution: Mediterranean and southern European. Two species are widespread and transported: *Octodrilus complanatus* and *O. transpadanus* (Rosa, 1884), either sometimes misspelt "*complanatum*" or "*transpadanum*"; both are listed from Argentina (e.g. Ref.1 ; Ref.2). See also Mischis & Brigada (1988) and Csuzdi & Zicsi (2003).

Key to Peregrine *Octodrilus* Species :

O. complanatus - Clitellum 28,29-37; TP 28,29-38,39; spermathecal pores 6/7-12/13.

O. transpadanus - Clitellum 29,30-37; TP 29,30-37; spermathecal pores 6/7-10/11.

Octodrilus complanatus (Dugès, 1828)

Fig. *Octodrilus complanatus* from T. Pavlicek website from photo by Cs. Csuzdi (2008).

Lumbricus complanatus Dugès, 1828: 289. [Types lost].

Allolobophora complanata: Rosa, 1884; Beddard, 1892: 29.

Lumbricus (Dendrobaena) complanatus: Vaillant, 1889: 117.

Allolobophora (Octolasion) complanatum: Rosa, 1893: 424.

Octolasion complanatum: Örley, 1885: 15; Michaelsen, 1900: 508; 1916: 21; Baldasseroni, 1919: 356. [Note: subspecies *O. complanatum kamnensis* Baldasseroni, 1919: 356 elevated to species level].

Octodrilus complanatus: Omodeo, 1956; Easton, 1983: 483; Blakemore, 2003, 2007, 2008; Szederjesi & Csuzdi (2012) (syn. *peleensis* Michalis, 1995).

Octodrilus peleensis Michallis, 1995 (synonym from Szederjesi & Csuzdi, 2012).

Diagnosis: Length 80-180 mm. Colour reddish brown. Prostomium epilobous. First dorsal pore 11/12/13. Spermathecal pores seven pairs in 6/7-12/13 in c lines. Clitellum 28,29-37. Tubercula pubertatis in 28,29-38,39. Setae widely paired.

Distribution: Mediterranean Europe: Portugal, Spain, southern France (Montpellier, Nizza), Azores, Italy, Sicily, Austria, Greece, Romania, Golan Heights (Csuzdi, 2005), Egypt, Syria, Algeria, Morocco; Ilha do Principe in Gulf of Guinea (Western Africa near Sao Tome); Canary Isles [e.g. Michaelsen (1916: 21) and Icod de los Vinos, Tenerife (Ref.)]; Buenos Aires, Argentina (Ref.).

Habitats: grasslands, pastures and under crops or trees.

Behaviour: stated to be both hermaphroditic and parthenogenetic.

Length: 80-180 mm.

Width: 7-10 mm.

Segments: 160-190.

Colour: Smoky brown to red-brown.

Prostomium: Epilobous.

First dorsal pore: 11/12/13.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment, widely separated; (2:1:1:0.5:6:?).

Nephropores: ?.

Clitellum: 28,29-37.

Male pores: Minute on15, not tumid.

Female pores: On 14.

Spermathecal pores: 6/7-12/13 in c lines (seven pairs).

Genital markings: Tubercula pubertatis 28,29-38,39.

Septa: ?

Dorsal blood vessel: ?

Hearts: ?

Gizzard: ?

Calciferous glands : ?

Intestine origin (caeca, typhlosole): ?

Nephridia: Holoic.

Male organs: Testes/funnels in testis sacs.

Ovaries: In 13.

Prostates: None.

Spermathecae: Seven pairs.

Gut contents: ?

Remarks: Differences of *Octodrilus complanatus* from *O. transpadanus* are given in the keys above. The genome size of *O. complanatus* is estimated at 0.86 pg (Vitturi *et al.*, 2002; Gregory & Herbert, 2002).

Its life-cycle in Spain was studied by Monroy *et al.* (2007).

Octodrilus transpadanus (Rosa, 1884)

Enterion opimum Savigny, 1826: 183 (part.). [Types?]. [Synonymy by Michaelsen (1900: 507) (priority!?). Misspelt "opium" in Reynolds & Cook, 1976: 148].

L. terrestris var. *stagnalis* : Örley, 1881: 583 (err., non Hoffmeister, 1845); Horst, 1887: 297.

Allolobophora transpadana Rosa, 1884: 45. [Type Moscow: 93].

Allolobophora transpadana cinerea Rosa, 1886: 679. [Types?].

Allolobophora cyanea recta Ribaucourt, 1896: 67. [Heustrich, Switzerland. Types?].

Allolobophora sulfurica Ribaucourt, 1896: 86. [Heustrich. Types?].

Allolobophora nivalis Bretscher, 1899: 420. [Types?].

Octolasion transpadanum: Örley, 1885: 19; Michaelsen, 1900: 508.

Octolasium transpadanum alpinum Bretscher, 1905: 1. [Types in Zurich]. [Non *Al. alpina* Rosa, 1884, nec *Al. roseus vedovinii* Bouché, 1972 (sic) nom. nov. pro *Al. rosea alpina* Vedovini, 1967. Cited as *Octolasium transpadana alpina* in

Reynolds & Cook, 1976: 68].

Octodrilus transpadanus : Easton, 1983: 483; Cuzdi & Zicsi, 2003: 215; Blakemore, 2004; 2006; 2007 (syns. as above and as noted below).

Taxonomic Remarks: Easton (1983: 483) has *O. transpadanus* (Rosa, 1884) with these synonyms: *opimum* Savigny, 1826 (part.); *transpadana cinerea* Rosa, 1886; *cyanea recta* Ribaucourt, 1896; *sulfurica* Ribaucourt, 1896; *nivalis* Bretscher, 1899; *transpadanum alpinum* Bretscher, 1905. Savigny's earlier taxon was considered a probable synonym since Michaelsen (1900: 507) who also listed *L. terrestris* var. *stagnalis* : Örley, 1881: 583 (err., non Hoffmeister, 1845) as a further synonym.

Diagnosis: Length 40-450 mm. Colour dark grey or brownish. Prostomium epilobous. First dorsal pore 12/13. Spermathecal pores five pairs in 6/7-10/11 in c lines. Clitellum 29,30-37. Tubercula pubertatis in 29,30-37,38,39. Setae widely paired.

Following account is modified from Michaelsen (1900); Csuzdi & Zicsi (2003: 215-217).

Distribution: Mediterranean and Central European: Italy, Sicily, Austria, southern Germany, Greece, Romania, Hungary, Switzerland, Transcaucus, northern Turkey (Ref.); Jordan (Csuzdi & Pavlicek, 2005: 71); Argentina - found in dam wall under plantation cypresses at San Luis (see Mischis & Brigada, 1988; Mischis, 2004: 266 also : http://www.efn.uncor.edu/dep/divbioeco/DivAni1/lombric/lombr_arg.htm Dec. 2005).

Habitats: All soil types, abundant in swamps and riverbanks, large body size in forests.

Behaviour: High cast production (see remarks below).

Length: Generally large body but size range given as, 40-450 mm.

Width: 4-10 mm.

Segments: 100-252.

Colour: Dark grey or brown.

Prostomium: Epilobous.

First dorsal pore: 12/13.

Setae (ratio of aa:ab:bc:cd:dd:U): 8 per segment, widely separated; (2:1:1:1:5:?).

Nephropores: Alternate irregularly between b and d or above.

Clitellum: ½29,30-37.

Male pores: Small on15 between b-c.

Female pores: On 14.

Spermathecal pores: 6/7-10/11 in c lines (five pairs).

Genital markings: Tubercula pubertatis 30-37.

Septa: 5/6-13/14 thickened.

Dorsal blood vessel: Single?

Hearts: Last pair in 11 plus extraoesophageals in 12.

Gizzard: 17-18.

Calciferous glands: In 10-12 with diverticula in 10.

Intestine origin (caeca, typhlosole): Typhlosole anchor-shaped.

Nephridia: Holoic with ocarina-shaped bladders.

Male organs: Testes/funnels in testis sacs (?); seminal vesicles 9-12.

Ovaries: In 13.

Prostates: None.

Spermathecae: Five pairs.

Gut contents: Occurs in most soils and in swamps and riverbanks?

Remarks: Differences of *Oc. complanatus* from *Oc. transpadanus* are given in the key above. Csuzdi & Zicsi (2003: 209) say that *Oc. gradinescui* (Pop, 1938) of Dacian origin (in Romania, Slovakia, Ukraine and Hungary) is close to *Oc. transpadanus*, but the clitella and setal ratios differ so that while *Oc. transpadanus* clitellum ends in 27 and has ab = cd, *Oc. gradinescui* clitellum occupies the all of 38 and ab = 1.5cd.

Annual cast production estimated as 2.23 kgm^{-2} with 80% deposited in the ground up to 1m deep (Csuzdi & Zicsi, 2003: 217).

Pop *et al* (2003) studied phylogenetic position from (non-type) molecular data.

Genus ***Octolasion*** Örley, 1885

Octolasion Örley, 1885: 10, 13.

[Syns. *Alyattes* Kinberg, 1867 (type-species: *Lumbricus alyattes* Kinberg, 1867 = *O. cyaneum*); *Octolasia* Rosa, 1893 (1896?): 3; *Octalosion* (laps.) Ribaucourt, 1896: 95; *Octolasium*: Michaelsen, 1900: 504 (invalid emendations); and *Octolasion* (*Incolore*) Omodeo, 1952 (type-species: *Lumbricus terrestris lacteus* Örley, 1881 (= *O. lacteum*))].

Type-species: *Lumbricus terrestris lacteus* Örley, 1881 (= *O. lacteum*) by subsequent designation (Omodeo, 1956; non Omodeo, 1952) and by ICZN (1986: Opinion 1403). Previously citations of type-species "O. lacteum *Örley, 1885 (*= Enterion tyrtaeum *Savigny, 1836)*", e.g. by both Gates (1972) and Reynolds (1977), are

incorrectly dated (also by Reynolds & Cook, 1976: 57); cf. Gates (1982: 27) also had the generotype = *tyrtaeum* by a similar oversight.

Diagnosis: Calciferous sacs large in 10-11, open vertically into the equator of oesophagus in 10. Calciferous lamellae continued onto posterior walls of each sac. Nephridial vesicles ocarina-shaped. Nephropores obvious, seemingly in a single rank along each side above b. Hearts 6-11. Pigment, if present, not red. Prostomium epilobous. Setae not closely paired.

Distribution: Palaearctic. The genus contains five species of European origin (Easton, 1983), two or three of these are especially widespread by adventitious transportation. Certain species previously included in *Octolasion* are accommodated in *Octodrilus* Omodeo, 1956 (type-species: *Lumbricus complanatus* Dugès, 1828).

Taxonomic Notes: Sims (1983: 471) commented on oversight of the strict priority of Kinberg's genus *Alyattes* over *Octolasion* that, in the interests of nomenclatural stability, required suppression of the former genus and continued usage of *Octolasion* - see Sims (1984), ICZN (1986). Name sometimes misspelt "Octalasion" or "Octalasium".

Cernosvitov (1931: 203) included *O. tyrtaeum* in *O. lacteum* – despite priority – whereas Gates (1972: 128) first mooted that *O. lacteum* (Örley, 1881) was a junior synonym of *O. tyrtaeum* which, according to Sims (1983: 471), has two French subspecies: *O. tyrtaeum tyrtaeum* (Savigny, 1826) and *O. t. gracile* (Örley, 1885). Nevertheless, Easton (1983: 483) lists both *O. lacteum* (Örley, 1881) and *O. tyrtaeum* (Savigny, 1826) as valid, with *O. gracile* (Örley, 1885) a junior synonym of the latter.

The inadequately described *Allolobophora tyrtaea* Ribaucourt, 1896 (?non *E. tyrtaeum* Savigny, 1826), based on a single specimen from Switzerland, although appearing to comply with *O. lacteum*, is placed as a junior synonym of *Proctodrilus antipae antipae* (Michaelsen, 1891) (often mispelt "antipai" this a central and southern European species is also reported from Algeria e.g. by Baha, 1997); it may yet be both homonym and synonym of *O. tyrtaeum* (see Gates, 1972: 128; Easton, 1983: 482).

Basic chromosome numbers of *Octolasion* are n = 18 or 19 from data in Gerard (1964) where he cites 180 for *O. cyaneum* (the highest recorded for any megadrile), and in his description for *O. lacteum*, which refers in part to *O. tyrtaeum*, he cites 38, i.e., n = 19 (cf. numbers given in the accounts below). The three common species, with their priority, are differentiated thus:

O. tyrtaeum (Savigny, 1826: 180) – male field ½14-½16, clitellum 30-35, TP 30-35 and often with setae ab within tumescences on segment 22 and adjacently.

O. cyaneum (Savigny, 1826: 181) – male pores confined to 15 but may dislocate 14/15 and 15/16, clitellum 29-34(,35), TP 29,30-33,34. Tip of tail bright yellow.

O. lacteum (Örley, 1881) – male pores may extend further than 15, clitellum 30-35, TP shorter in 31-34 only, (no tumescences around setae a on 22 cf. *O. tyrtaeum*).

Distributions from Sims & Gerard (1999: 112, 116) are of *O. cyaneum* and *O. t. lacteum* widely distributed in Europe and worldwide, whereas *O. t. tyrtaeum* is from south-eastern France through to central Europe. Differences between the latter two may be artificial as intergrades are apparently known e.g. by Stöp-Bowitz (1969) and Reynolds (1977) who both only considered priority with *O. lacteum* or *O. tyrtaeum*, respectively, cf. current specimens.

Summary of confusion of the genus is that *O. cyaneum* appears a 'good' species whereas *O. lacteum* is sometimes combined or confused with *O. tyrtaeum* e.g. by Gates (1972) vs. Csuzdi & Zicsi (2003), or sometimes retained as a subspp of prior *tyrtaeum.*

Octolasion cyaneum (Savigny, 1826)

Fig. 6.22a. *Octolasion cyaneum* Scullin ACT specimen (a) ventral view (b) prostomium.

Fig. 6.22b. *Octolasion cyaneum* from Strathgordon Tas. (a) ventral view (b) prostomium.

?Lumbricus terrestris (part): Müller, 1774: 24.

Enterion cyaneum (part) Savigny, 1826: 181. [Type locality Paris. Types in Paris Museum – three specimens, a fourth may be *tyrtaeum* (see Gates, 1972:128)]. [Non *L. communis cyaneus* Hoffmeister, 1845 (= *A. caliginosa*)].

Lumbricus Cyaneus: Dugès, 1837: 17. [Types?].

Lumbricus stagnalis (part?) Hoffmeister, 1845: 35, figs. 7a, b (?residue = *O. lacteum*). [Types missing].

Lumbricus alyattes Kinberg 1867: 99. [Type Stockholm, 1935].

Allolobophora studiosa Michaelsen, 1890: 50; Ribaucourt, 1896: 64. [Type lost]

Allolobophora (Octolasion) cyanea (part - see *A. turgida*) + *Allolobophora cyanea stagnalis*: Rosa, 1893: 424, 455.

?*Allolobophora cyanea* : Ribaucourt, 1896: 59.

Allolobophora (Octolasion) cyanea studiosa : Ribaucourt, 1896: 95.

Helodrilus (*Dendrobaena*) *kempi* Stephenson, 1922: 441. [Locality Kufri, Simla Hill States, India. Types in Calcutta and British Museum].

Dendrobaena jeanneli Pop, 1948. [Type in Cluj]. [This new synonym from Szederjesi & Csuzdi (2012)].

Octolasion cyaneum var. *armoricum* Bouché, 1972: 260. [Types in France]. [Overlooked by Qiu & Bouché (1998: 192)] this synonymy by Csuzdi & Zicsi (2003: 193), thus the nominal subspecies also returned to specific status].

Octolasion cyaneum: Michaelsen, 1900: 506 [syn. *stagnalis* (part?), *alyattes*, *studiosa*]; Lee, 1959: 368; Stöp-Bowitz, 1969: 204, fig. 24; Gates, 1972: 123; Gerard, 1964: 49; Easton, 1983: 483 (syn. *stagnalis*, *alyattes*, *studiosa*, *kempi*); Sims & Gerard, 1985; 1999: 112, fig. 40; Blakemore, 2004; 2006; 2007.

Note: Some N. American studies confused *O. cyaneum* for *Bimastos welchi* (F. Smith, 1917: 174).

Diagnosis: Length 52-220 mm. Colour whitish or greyish, white ring of calciferous sacs shows through cuticle in about 10, tip of tail often yellow, clitellum orange. Prostomium epilobous. First dorsal pore 9/10-13/14. Spermathecal pores 9/10/11 just above c lines. Clitellum 29-34(,35). Tubercula pubertatis uninterrupted longitudinal bands lateral to b lines in ½29,30-33,½34; genital tumescences around a and/or b on 8-10 and sometimes 17-20,21, 22. Setae widely paired.

Distribution: Europe and Scandinavia: Russia, Poland, Germany, Benelux, British Isles and Ireland, Czech and Slovak Republics, Romania, Hungary, Switzerland, France, Portugal, Spain. Introduced into Faeroes, Iceland, Azores, North America and Canada, Mexico, South America (e.g. Brazil by Righi, 1967, also Ecuador, Chile, Argentina, Mexico & Uruguay by Brown & Fragoso, 2007 and Colombia by Fajardo & Prince, 1976 and Tulande *et al*., 2018), India, Pakistan, South Africa [one record from a garden at Eagle Ridge Forest Resort, near Stutterheim also recently from a Pietermarizburg park by Nxele (2012)]; widespread in NZ (Lee, 1959: 369) and Australasia. Previous Australian records from ACT (collector K.R. Norris, 1951); Jenolan Caves in Blue Mtns., NSW (Michaelsen, 1907a: 24); Nowra, NSW (Stephenson, 1933:940); Northbridge, Sydney (collector F. McCarthy, 1962); Mt Kosziusko, NSW (Wood, 1974); Vict (Tisdall, 1985); WA (Abbot, 1981). New records are from SA, NSW, ACT and Tas. (Blakemore, 1994; 1996; 1999; 2000) (cf. *O. lacteum*).

Locality: Adelaide, SA; Mt. Lofty near Toowoomba on the Great Dividing Range Qld (collector D. Crossman, 1971); Budderoo, NSW; Scullin and Kippax, ACT (collectors Seb and Zac Blakemore), and widespread in Tas. Qld and Tas new records for Australia.

Habitat: Under stones in water, in moist soil under logs; in forest (or plantation), arable

and garden soils. This species is common in pastures but also occurs where there are cattle and human trails through bushland (e.g. NZ and Tasmania) and at altitude of 3,100 m (Tulande *et al*., 2018). Gates (1972: 125) cites a report in the medical literature of a specimen of *O. cyaneum* lodging in a woman's vagina for more than a year (cf. *Dichogaster bolaui* and *Eisenia fetida* habitats – see Blakemore, 2013).

Behaviour: remains flaccid and docile when handled.

Length: 52-220 mm.

Width: 5-8 mm.

Segments: 100-165, some secondary annulation dorsally; body cylindrical in anterior but flattened or octagonal posteriorly.

Colour: Blue-grey or milky white with lilac mid-dorsal line, often the calciferous sacs in 10 show through the cuticle as a whitish ring, and the tip of the tail is yellow due to accumulation of coelomocytes; clitellum white to orangy-red.

Prostomium: Open or closed epilobous.

First dorsal pore: 9/10-13/14.

Setae (ratio of aa:ab:bc:cd:dd:U/12): Small, 8 per segment closely paired anteriorly becoming wide pronounced after clitellum; setae a especially large and dark; (4:1:2.5:1:12:0.47).

Nephropores: Obvious, at least behind 15 in a single rank on each side just above b lines.

Clitellum: Prominent saddle-shaped, 29-34, cleft ventrally at 31/32 (as is *A. caliginosa*!); [note that Tulande *et al*., 2018 record it in 29-34,35].

Male pores: Confined to 15 nearer to c than to d setae, lateral slits with pale slightly tumid lips.

Female pores: Small slits lateral to b in 14.

Spermathecal pores: 9/10-10/11 just above c in cd lines but often concealed in furrows.

Genital markings: Tubercula pubertatis uninterrupted longitudinal bands lateral to b lines in 29,30-33,34 (furrowed 31/32 cf. *lacteum*), sometimes absent (e.g. Scullin specimen); genital tumescences around a and/or b on 8-9 (e.g. Tasmanian material), or on 10 and sometimes on some of 17-20, 22, often on 19 (and slightly tumid around ab in 20-28 in Strathgordon material, cf. *O. tyrtaeum*).

Septa: 5/6-15/16 strengthened, 17/18 distended to base of gizzard.

Dorsal blood vessel: Single.

Hearts: 6-11 (extraoesophageals in 12).

Gizzard: 16-17 or 17-18, preceded by a large crop.

Calciferous glands: As large lateral sacs in 10-11 (or 11-12 Stephenson, or 10-12 Csuzdi & Zicsi) with lamellae on lateral walls only, opening into oesophagus in 10.

Intestine origin (caeca, typhlosole): 15; bifid or broad circular typhlosole beginning behind 19; (called anchor-shaped by Csuzdi & Zicsi).

Nephridia: Holoic, bladders present (ocarina-shaped).

Male organs: Testes/funnels in 10 and 11 in testis sacs; seminal vesicles in 9-12, those in 10-11 often rudimentary.

Ovaries: Compact in 13; ovisacs in 14.

Prostates: None.

Spermathecae: Two pairs sessile in 10 and 11, adiverticulate.

Gut contents: Fine soil, or dark soil and organic matter.

Notes: Stated to have parthenogenetic reproduction, the chromosomes numbers quoted by Gates (1972: 124) are 144, 180, 190 (%15-20?) n = 19; while Sims & Gerard (1985: 112) quote n= 180 i.e., n = (19 X 10)-10. The species is said to be 'homodynamous' or without diapause and it is mostly active in surface soils with casting below the surface but sometimes also above ground. Submersion in water for 6 weeks produced no ill effects. As Gates (1972: 125) noted, earlier questions of the distinction of this taxon from *O. tyrtaeum* were due to differences only of the clitellum, but besides issues of parthenogenetic reproductive the various other morphological differences between these taxa are noted after the generic and species diagnosis above and below.

Octolasion lacteum (Örley, 1881)

Fig. 6.23 *Octolasion lacteum* from Blue Mountains, NSW (a) ventral view with (b) dorsal view of prostomium, (c) spermathecae and (d) nephridial bladder.

[?*Enterion tyrtaeum* Savigny, 1826: 180 – cf. *O. tyrtaeum*].

?Lumbricus communis cyaneus + *L. stagnalis* (part – see *O. cyaneum*) Hoffmeister, 1845: 24, fig. 3a, 35, fig. 7a, b. [Types lost].

Lumbricus terrestris var. *lacteus* Örley, 1881: 584. [Type locality Hungary. Types in Berlin, 5018]. [Cf. Reynolds & Cook, 1976: 125 have "*lacteum* Örley, 1885: 21"]. [Non *Allolobophora lactea* Friend, 1892 (= *Ap. longa*)].

Lumbricus terrestris var. *rubidus* Örley, 1881: 584. [?Types in Leiden]. [Non *rubidum*

Savigny, 1826 (= *Dendrodrilus rubidus*)].

Allolobophora rubidus : Örley, 1884: 584; Ribaucourt, 1896: 65.

Allolobophora profuga Rosa, 1884: 47, fig. 9. [Types?]; Ribaucourt, 1896: 60.

?*Octolasion profugum* + *gracile* + *lacteum* : (part?) Örley, 1885: 17, 18, 21.

Lumbricus (*Allolobophora*) *profuga* : Vaillant, 1889: 113.

Allolobophora cyanea profuga var. *sylvestris* Ribaucourt, 1896: 67, 95. [Types?].

?*Allolobophora tyrtaea* Ribaucourt, 1896: 87. [A single specimen from Switzerland (type?)]. (?Non *E. tyrtaeum* Savigny, 1826). [Probably a redescription of Savigny's *tryraeum*, although it appears to comply with *O. lacteum*, it is most often placed as a synonym of *Proctodrilus antipae antipae* (Michaelsen, 1891)].

Octolasion lacteum (part): Michaelsen, 1900: 506 (syn. *rubidus*, *profuga*, *sylvestris*); Gerard, 1964:50. [Excl. (part) = *O. tyrtaeum* components]; Smith, 1917: 178 (syn. *profuga*).

Octolasium lacteum (part): Cernosvitov, 1931: 203 (includes *tyrtaeum* despite priority).

Eophila himalayana Cernosvitov, 1937: 109. [Types?].

Octolasion tyrtaeum (part): Gates, 1972: 125, 128; Reynolds, 1977: 108. [Excl. (part) = *O. tyrtaeum* components].

Octolasion lacteum: Stöp-Bowitz, 1969: 207, fig. 27 (part? syn. *tyrtaeum*) ; Easton, 1983: 483 (syn. *terrestris rubidus* Örley, 1881; *profuga* Rosa, 1884; *cyanea profuga sylvestris* Ribaucourt, 1896; *himalayana* Cernosvitov, 1937); Csuzdi & Zicsi, 2003; Blakemore, 2004; 2005; 2006; 2007 (syns. as above and below).

Octolasion lacteum lacteum: Bouché, 1972: 253.

?*Octolasion lacteum gigantheum* Mrsic, 1983: 56. [Types?]. [Overlooked by Qiu & Bouché (1998: 192); in synonymy of *lacteum sensu* Csuzdi & Zicsi (2003)].

Note: Account by Gerard (1964) of *lacteum* refers in part to *tyrtaeum*; conversely, accounts by Gates (1972) and Reynolds (1977) of *tyrtaeum* include *lacteum* while Csuzdi & Zicsi (2003: 198) ignore the prior *tyrtaeum* in favour of *lacteum* for the mistaken reason that Michaelsen (1900: 513) had it as *incertae sedis*. Cf. *O. tyrtaeum* account below. Actually, if these two names are synonyms, then *tyrtaeum* takes priority. [Following description is from Gerard (1964), other sources, and pers. obs.].

Diagnosis: Length 35-160 mm. Colour whitish or greyish. Prostomium epilobous. First dorsal pore 8/9-10/11. Spermathecal pores 9/10/11 above c in cd lines. Clitellum 30-35. Tubercula pubertatis 31-34; genital tumescences absent or around a and/or b on some of 9-12, 14, 17, 19-23, 27, 37, or 38 (i.e., not on 22). Setae widely paired.

Distribution: Widely distributed but not common in Pyrenees, eastern France through to Central Europe. Introduced reports are confused with *O. tyrtaeum*, but may include Algeria, Azores, Canaries (Ref.), Corsica, Iran, China (Manchuria), Turkestan, northern India, Australia (NSW); South America (Brown & Fragoso, 2007): Brazil, Ecquador, Peru, Bolivia, Colombia, Panama, and Uruguay, Mexico (e.g. Gates, 1942), Chile (Unduavi, La Paz, 4.654m – Sielfeld, 2002), Argentina (Tierra del Fuego – Mischis & Moreno, 2003), South Africa (reported under its various synonyms), and North America (Gerard, 1964), e.g. described from Ohio by Olsen (1933). [Cf. *O. tyrtaeum* distribution which is stated by Sims & Gerard (1999: 116) to spread from Pyrenees and eastern Frace to central Europe].

Locality: Blue Mountains, NSW, Coll: AMBS, 3.xi.1996; Australian Museum specimen AM:W.24431.

Habitat: Terrestrial in moist soil, occasionally limnic, also found under stones.

Behaviour: ?

Length: 35-160mm; current specimen 30 mm.

Width: 3-5 mm.

Segments: 87-165 (current specimen 75); body cylindrical, slightly octagonal posteriorly.

Colour: Blue-grey or milky white; clitellum pink or orange; uniform buff in alcohol.

Prostomium: Epilobous.

First dorsal pore: 8/9-10/11, usually 10/11.

Setae (ratio of aa:ab:bc:cd:dd:U/12): 8 per segment not closely paired (ab>bc>cd).

Nephropores: Obvious, in a single rank on each side just above b lines.

Clitellum: Saddle-shaped 30-35.

Male pores: Have relatively large papillae extending into 14 and 16 although occasionally confined to 15.

Female pores: On 14.

Spermathecal pores: 9/10-10/11 just above c in cd lines; or just below c lines in current specimen.

Genital markings: Tubercula pubertatis ½30,31-34,½35 (furrowed 32/33 cf. *cyaneus*), but more usually 31-34 only; genital tumescences absent or around a and/or b on on some of 9-12, 14, 17, 19-23, 27, 37 or 38 (i.e., not on 22).

Septa: None especially strong although from 6/7 slightly thickened.

Dorsal blood vessel: single.

Hearts: 6-11.

Gizzard: 17; or large in 19-20 in current specimen.

Calciferous glands: As large lateral sacs in 10 (or 10-12) with lamellae on lateral walls only, opening into oesophagus in 10.

Intestine origin (caeca, typhlosole): 15?; lamellar typhlosole soon after gizzard.

Nephridia: Holoic, bladders present and ocarina-shaped (in current specimen).

Male organs: Testes/funnels in 10 and 11; seminal vesicles in 9-12, those in 9-10 small.

Ovaries: In 13.

Prostates: None.

Spermathecae: Two pairs sessile, sperical; not iridescent.

Gut contents: Gut contains dark soil but in the gizzard are many quartz grits (crop stones?).

Notes: Chromosomes number is 38 (n= 19?) (Gerard, 1964). A species which Fletcher (1887a) obtained from Sydney, while not agreeing exactly, came "nearest to *Allolobophora profuga* Rosa, 1884" (= *Octolasion lacteum*) and is probably referrable to this species, indicating an early occurrence in the colony. Several other reports of *O. lacteum*, which is often confused and may be in synonymy with *O. tyrtaeum* (see Gates, 1958b), possibly refer to *O. cyaneum*.

Gerard, who partly confused *O. tyrtaeum* with *O. lacteum*, says that it is widespread but never very abundant with habitats similar to *O. cyaneum* but that these two taxa seldom occur together.

Octolasion tyrtaeum (Savigny, 1826)

Fig. 6.24 *O. tyrtaeum* from nr. Greymouth NZ (nephridial bladder is in 9lhs).

Enterion tyrtaeum Savigny, 1826: 180. [Type locality Ile de France, Paris. Type in Paris Museum stated to be missing by Gates (1972: 125) cf. *O. cyaneum* types. However, on p. 128 Gates says "*Only three individuals of* Octolasion *(and perhaps a fragment of a fourth,* ***possibly the type of*** **tyrtaeum***), all of* cyanea*, are in Savigny's collection at the Paris Museum.... Only one specimen* [of *tyrtaeum*] *may have been available to Savigny and most if not all of it may have been discarded after the dissection.... Clearly then there are no types. Finally , in Europe from the region north of Paris, all worms with a clitellum of six segments in xxx-xxxv have been referable to morphs of the taxon that now must be known*

as tyrtaeum.". The DNA of the 'type', **bolded** above, may be compared to these latter specimens (or they may provide a neotype?), for resolution of these two taxa].

Lumbricus tyrtaeus : Duges, 1837: 17, 22.

Octolasion gracile Örley, 1885: 16,18. [Types in Berlin, 5019].

Lumbricus (*Octolasion*) *gracilis* : Vaillant, 1889: 113.

?*Allolobophora tyrtaea* Ribaucourt, 1896. [A single specimen from Switzerland]. (?Non *E. tyrtaeum* Savigny, 1826). [Appearing to comply with *O. lacteum*, it is often placed as a synonym of *Proctodrilus antipae antipae* (Michaelsen, 1891)].

Octolasion lacteum (part): Michaelsen, 1900: 506 (syn. *gracile*); Gerard, 1964: 50; Csuzdi & Zicsi (2003: 197) (syn. *rubidus, profuga, gracile, sylvestis, himalayana, gigantheum*). [Excluding (part) = *O. lacteum* components].

Lumbricus tyrtaeus: Michaelsen, 1900: 509, 513 [erroneously stated to be *incertae sedis* in Csuzdi & Zicsi (2003: 198) as their justification for ignoring this taxon]. [Michaelsen give Clitellum in 30-35, TP in 31-34, i.e., same as for *lacteum*].

Octolasium lacteum : Cernosvitov, 1931: 203 (syn. *tyrtaeum*).

Octolasion tyrtaeum (part): Gates, 1972: 125-128; Reynolds, 1977: 108, fig. 38. [Excluding (part) = *O. lacteum* components].

Octolasion lacteum gracile: Bouché, 1972: 257.

Octolasion tyrtaeum: Easton, 1983: 483 (syn. *gracile* Örley, 1885); Blakemore, 2007.

Octolasion tyrtaeum tyrtaeum: Sims & Gerard, 1985, 1999: 115/6, fig. 41 (showing TP ½30-½35), (syn. *lacteum* (part), *lacteum gracile*).

Octolasion tyrtaeum tyrtaeum + *O. t. gracile*: Qiu & Bouché, 1998: 192 (who also misspell the name "*tyrtaeum tyraeum*").

Note: Some accounts, e.g. by Gerard (1964), Stöp-Bowitz (1969) and Csuzdi & Zicsi (2003) of *lacteum* refer in part to *tyrtaeum*; conversely, accounts by Gates (1972) and Reynolds (1977) of *tyrtaeum* include *lacteum*. The characteristics, if any, distinguishing the two taxa are often intermingled and difficult to separate with any confidence but Sims & Gerard (1999: 116) state that *O. t. lacteum* has a shorter tubercula pubertatis, in segments 31-34 only, and lacks genital tumescences around setae ab on 22 compared to *O. t. tyrtaeum*.

Some authors are mistaken on the point that Reynolds & Cook (1993: 28) say the taxon is invalid as Reynolds & Cook (1993: 28) only say their earlier date "Sav. 1926" was a *lapsus calami pro*: Sav, 1826 **not** that the name *tyrtaeum* was a *lapsus*. Cs. Csuzdi

(pers. comm. April, 2011) doubts the validity of genus placement, but this again does not negate the species name if properly formed and valid nomenclaturally.

[The following account is derived from authorities above, attempting to exclude their *O. lacteum* components (and its synonyms)].

Diagnosis: Length 30-160 mm. Colour whitish or greyish with pale clitellum. Prostomium (closed) epilobous. First dorsal pore 8/9-12/13. Spermathecal pores 9/10/11 above c in cd lines. Clitellum 30-35. Tubercula pubertatis 30,½30-35; genital tumescences around a and/or b and often cd on on 8-12, also around a and/or b setae on (21), 22, (23). Setae relatively widely paired, especially after clitellum.

Distribution: Records are confused with *O. lacteum*, but (mainly from Stöp-Bowitz and from Gates) may be widespread but seldom numerous in southern and western Europe, Middle East, Urals to Siberia, China (Manchuria), Turkestan, Tartar Republics, Khazakstan, Iran; with introduced populations in much of North America, Mexico City, South America (e.g. Colombia, Argentina), Juan Fernandes Isls. Chile by Gates (1969: 4), South Africa, India (from Himachal Pradesh, Jammu and Kashmir, Sikkim, Tamil Nadu, Uttarakhand, Bengal and, recently, from Kerala as a new record – paper in press 2018), Australia [unconfirmed] and a few other oceanic islands. Cf. Sims & Gerard (1999) who say it is mainly in southestern France through to Central Europe. A **new record** is for New Zealand: collected 13th Nov., 2010 by RJB from soil on rockface near beach on Punaikaki Rd. close to Greymouth on West coast of South Island (Blakemore 2010, 2011, 2012).

Locality: This single New Zealand record supports the conclusion that it is relatively rare and mainly confined to Europe.

Habitat: Under stones and logs, decaying leaves, compost, peat, in soils of pH 4.3-8.1. In taiga, forests, steppes, mull, pasture, arable land and gardens being more abundant in moist soils, bogs, caves, stream banks and the roots of submerged plants. It has been said to be stenotopic, eurtopic, as well as amphibious.

Behaviour: ?

Length: 25-160 mm (current specimens ca. 70 mm).

Width: 2.5-6 mm.

Segments: 87-165, body cylindrical, slightly octagonal posteriorly.

Colour: Whitish grey to blue, rarely rosy pink or brownish, unpigmented; clitellum pale.

Prostomium: Epilobous (closed).

First dorsal pore: 8/9-12/13.

Setae (ratio of aa:ab:bc:cd:dd:U/12): 8 per segment not closely paired (2:1:1:1:4.5:?).

Nephropores: Obvious, in a single rank on each side just above b lines.

Clitellum: Prominent saddle-shaped 30-35.

Male pores: Lateral of b on 15, male pore tumescence in bc obliterates and extends beyond 14/15 and 15/16.

Female pores: In 14 lateral to b.

Spermathecal pores: 9/10-10/11 just above c in cd lines.

Genital markings: Tubercula pubertatis 30,½30-35; genital tumescences around a and/or b and often cd on on 8-12, also around ab setae on (21), 22, (23); most obvious around ab in 21 and 22 in current NZ specimen.

Septa: 6/7-14/15 slightly thickened.

Dorsal blood vessel: Single.

Hearts: 6-11 (heart appears to be in 12rhs in current specimen, but this is almost certainly due to damage of septum during dissection which cut the dorsal vessel).

Gizzard: Large in 17.

Calciferous glands: As large lateral sacs in 10 which extend into 11 with lamellae on lateral walls only, opening into oesophagus in 10.

Intestine origin (caeca, typhlosole): 15 and 16 as large crop (proventriculus); low rounded typhlosole beginning in region of 20-24.

Nephridia: Holoic, bladders said to be ocarina-shaped are more sausage-shaped in current NZ specimen.

Male organs: Testes/funnels in 10 and 11; seminal vesicles in 9-12, larger in 11 and 12; in current NZ specimen, the testis are not iridescent in 10, seminal vesicles are small in 9 and absent from 10 suggesting incipient metandry (i.e. transitional loss of testis in 10).

Ovaries: 13 (small).

Prostates: None.

Spermathecae: Two pairs sessile, bulbous in 10 and 11.

Gut contents: Soil indicating a geophageous diet.

Notes: Obligatorily parthenogenetic, with chromosomes numbers of 38 (cf. *lacteum*), 54, 72, 144, n = 19 (Gates, 1972). Spermatophores are sometimes reported, but may not be fertile. Cocoons are laid once every three days and, after an incubation of 1-2 months, only one hatchling emerges; life span is estimated at about 2 years (Gates, 1972).

O. tyrtaeum has been classed as sedentary, inhabiting surface layers of the soil, leaving there only to hibernate (facultatively at depth), and also as a deep burrowing

species. It shares dominance in the "*Deschampietum*" of Russia with *Dendrobaena octaedra*, and in alluvial grounds of the same regions with *Eisenia nordenskioldi*.

Cernosvitov (1931) and Gates (1972: 128) both combined Örley's Hungarian *lacteum* with Savigny's prior *tyrtaeum* originally described from France that had been overlooked since Michaelsen (1900: 513) placed it outside the *Octolasion* ambit in *Lumbricus*. Örley's later taxon, *gracile*, although resurrected by some French authors, is more usually placed in synonymy with *tyrtaeum*. Easton (1983), without providing details, had maintained *lacteum* separately from *tyrtaeum* although these two taxa may eventually be better combined under *O. tyrtaeum*. If this happens then the distributions and habitats will also be combined. Previous reports from NZ probably refer to *lacteum*.

Gates (1972: 128) appears to have confused Ribaucourt's (1896) *Allolobophora tyrtaea* and Wessely's (1920) account of it with *O. tyrtaeum*. This taxon is usually placed as a synonym of *Proctodrilus antipae* (Michaelsen, 1891), e.g. by Easton (1983: 482), although Csuzdi & Zicsi (2003: 224) omit or overlook it.

Proctodrilus Zicsi, 1985.

Type species: *Allolobophora antipae* Michaelsen, 1891.

Included Species:

Pt. antipae antipae (Michaelsen, 1891: 16) **Emend.** Blakemore (2007, 2008) (restoration from "antipai") (syn. ?*tyrtaea* Ribaucourt, 1896; *riparia* Bretscher, 1901 [non Hoffmeister, 1843; restored from syonymy in *Ap. handlirschi* (Rosa, 1897) by Zicsi (1982)]; *cuginii helodriloides* Chandebois, 1957/8). [Note: Michaelsen (1900: 498), Reynolds & Cook (1976: 71), Easton (1983: 482) and Cherevatov (1994, 2000) use the original spelling *antipae*, but the name often spelt "antipai" e.g. Zicsi (1982), Omodeo & Rota (1989: 194; 2004: 240), Qiu & Bouché (1998: 197), and Csuzdi & Zicsi (2003: 224) presumably on the basis that the taxon was named from the modern name of a man in the genitive case (e.g., ICZN, 1999: Art. 31.1.2 Examples). However, ICZN (1999: Art. 31.1.1 Examples) appears to allow the "e" ending, even if based on a man's name, when the name is treated as a latinized noun in the genitive case to agree with the genus gender, and this is possibly the intention of Michaelsen (1891) as his original spelling is ostensibly the same in Michaelsen (1900: 498). This taxon previously held in *Helodrilus* with the highly dubious and athecal *tyrtaea* Ribaucourt, 1896 synonym after Easton (1983: 482), albeit Csuzdi & Zicsi (2003: 224) omit this synonym].

Pt. antipae vogesianus (Tétry, 1938) [sometimes (mis)spelt "*antipai vogesiana*"].

Pt. opisthoductus Zicsi, 1985.

Pt. thaleri Höser & Zicsi, 2009.

Pt. tuberculatus (Cernosvitov, 1935); [originally *Eophila antipae* var. *tuberculata*, this previous secondary junior homonym, from Reynolds & Cook (1976: 183), of *Allolobophora turgida tuberculata* Eisen, 1874 was removed by transfer to *Helodrilus* and more recently to *Proctodrilus* where it is sometimes (mis)spelt "*antipai tuberculatus*"; elevated to specific status by Zicsi (1985; 1991) and Csuzdi & Zicsi (2003: 229). Non *Al. antiqua tuberculata* Tzelepe, 1943 (= *Spermophorodrilus* ***tzelepei*** Blakemore, 2004: 78)].

Remarks: Only a few species, distinguished in table below, that are similar to genus *Helodrilus*.

Distribution: The type species, *Proctodrilus antipae antipae* (Michaelsen, 1891), is a central and southern European species also reported from Algeria e.g. by Baha (1997).

Table of characters of these similar species from Höser & Zicsi (2009)

Clitellum	Tubercula pubertatis	Receptacula seminis	Vesiculae seminales	Länge in mm	Art
25–33	30, 31	2	11, 12	35–40	*P. antipai*
26–33	30/31, 31/32	2	11, 12	50–60	*P. tuberculatus*
25, ½ 25–33	30-31	2	11, 12	25–75	*P. opisthoductus*
24–32	½ 28–½ 31	2	11, 12	35–55	*P. thaleri* sp. nov.

Genus ***Prosellodrilus*** Bouché 1972

Type-species: *Prosellodrilus idealis* Bouché, 1972.

Diagnosis: The genus *Prosellodrilus* Bouché 1972 was reviewed Qiu & Bouche (1998) and by Blakemore (2004, 2006, 2007, 2008).

Distribution: Mainly confined to mediterranean France, the type-species, *Prosellodrilus amplisetosus* Bouché, 1972, was reported from an Urban farm in County Dublin and a farm in County Loath, (Keith & Schmidt, 2012 and http://www.ucd.ie/earth/people/academic/olafschmidt/publications/); however, on inspection it was a new species *Kenleenus armadas* Blakemore, 2012. Baha & Bera (2001) (Ref.) give examples in Algeria and suggest splitting the genus into two subgenera: the nominal one including the species living in southwestern France, and a new subgenus, *Maghrebella*, inhabiting the Maghreb and Sardinia.

Remarks: Similar worms are found in in America in genus *Bimastos* e.g. both

Bimastos giessleri (Ude, 1895) and *Bimastos giesseleri hempeli* (Smith, 1915) that have in the past been put in synonymy of *Bimastos tumidus* (Eisen, 1874) (syn. *Bimastos ducis* Stephenson, 1933). Another superficially similar lumbricid, *Eisenia anzac* Blakemore, 2011, was recently recorded from Japan – (see www.senckenberg.de/files/content/forschung/publikationen/soilorganisms/volume_83_2/06_artikel_blakemore.pdf). The species will be briefly described here in due course...

Genus ***Satchellius*** Gates, 1975

Enterion Savitny, 1826: 179 (part.).

Dendrobaena Eisen, 1873: 53 (part.).

Helodrilus (Dendrobaena); Michaelsen, 1900: 488 (part.).

Satchellius Gates, 1975: 4; Blakmore 2004: 90..

Type-species: *Enterion mammale* Savigny, 1826:181 from Paris (and Brest?).

Diagnosis: Calciferous sacs open posteriorly and ventrally into the oesophagus of segment 10 just in front of 10/11. Calciferous lamellae continue along lateral walls of each sac. Nephridial vesicles sausage-shaped. Nephropores obvious, alternating irregularly on each side above b. Pigment red (or dark). Prostomium epilobous. Setae not closely paired. Its chromosome number is 2n=34 (Gerard, 1964: 36).

Distribution: Monotypic (subsequently species added from Franco-Iberian region). Western Europe, from Germany to Spain, and north-westwards to Channel Isles, England, Wales, Scotland, and Ireland (an area roughly coincident to that settled by Celts – as noted by its type-species' synonym). Widespread in soils with high organic content but seldom abundant. Four specimens of *Satchellius* were reported from New Jersey by Reynolds (1977: 116, after Gates, 1959?).

Taxonomic Notes: *Satchellius mammalis* was transferred from *Dendrobaena* by Gates (1975). Gerard (1964) also comments on its similarity to *Dendrobaena octaedra* (Savigny, 1826: 183) which may itself form a parthenogenetic species-complex with *D. attemsi* (Michaelsen, 1903) and *D. pygmaea* (Savigny, 1826:183) (e.g. Gates, 1972:92), and if *Satchellius mammalis* (Savigny, 1826:181) is implicated, then either *octaedra* and *pygmaea* compete for page priority, or else *mammalis* takes precedence overall. Easton (1983: 484) lists junior synonyms of *S. mammalis* as *celtica* Rosa, 1886 and *celtica*

rosea Friend, 1893 whereas Michaelsen was unaware of the latter taxon, or rather its dubious taxonomic publication. Genus sometimes misspelt "Sachellius".

Satchellius mammalis (Savigny, 1826)

Fig. *S. mammalis* from Sims & Gerard (1999: fig. 42).

Enterion mammale Savigny, 1826: 181. [Locality Paris & Brest. Type in Paris].

Lumbricus mammalis : Duges1837: 17, 22 fig. 7, 8.

Allolobophora celtica Rosa, 1886: 1. [Types in Turin, 511].

A. (Dendrobaena) celtica : Friend, 1892: 297 tab. 21, fig. 8, 9.

Dendrobaena celtica : Friend, 1893: 19.

Dendrobaena celtica rosea Friend, 1892/3: 187, fig. 2, Tab. [Epping forest. Types?].

A. (D.) amammalis (laps.), *A. mammalia* (laps.); Ribaucourt, 1896: 94.

Helodrilus (*Dendrobaena*) *mammalis*: Michaelsen, 1900: 493 (syn. *celtica* + Ribaucourt's 1896 lapsae).

Dendrobaena mammalis : Gerard, 1964: 36.

Satchellius mammalis : Gates, 1975a: 1; Easton, 1983: 484 (syn. *celtica* Rosa, 1886; *celtica rosea* Friend, 1893); Sims & Gerard, 1985; 1999:118, fig. 42. Blakemore, 2004: 112; 2005; 2006; 2007.

Diagnosis: Length 24-42 mm. Colour red or violet, strongly pigmented. Prostomium epilobous. First dorsal pore (4/5)5/6(6/7). Spermathecal pores 9/10/11 above c lines. Clitellum 31-36. Tubercula pubertatis 33&34; genital tumescences around a, b and c on on 9, also around a b setae on some of 25,26,31,32,35,36. Setae widely paired.

Distribution: As for the genus: Western Europe (Friend first collected it in UK – see below) and one report from USA (New Jersey) by Davies (1954: 4).

Locality: Collected by RJB at Y Plas Machynlleth, 22nd VI 2013 (specimen in NHM).

Habitat: Under moss and woodland litter; organic and moist soils (pH 4.3-8.2), rarely reported from arable fields as well as woodlands, e.g. Rothamsted report (2017: 50).

Behaviour: Sometimes arborial(?); produces spermatophores.

Length: 24-41 mm.

Width: 1.5-3 mm.

Segments: 83-100, body cylindrical, slightly depressed posteriorly.

Colour: Red or violet, deeply pigmented and iridescent.

Prostomium: Epilobous.

First dorsal pore: (4/5)5/6(6/7).

Setae (ratio of aa:ab:bc:cd:dd:U/12): 8 per segment widely paired (2:1:1:1:3:?).

Nephropores: Alternate irregularly above b lines.

Clitellum: Saddle-shaped 31-36.

Male pores: In bc on 15, large male fields extend to 13/14 and 16/17.

Female pores: In 14 lateral near position of b setae that may be suppressed.

Spermathecal pores: 9/10/11 just above c lines.

Genital markings: Tubercula pubertatis 33 & 34; genital tumescences around ab and often c on on 9 (and 11), also around ab on some of 25,26, 31,32,35,36.

Septa: 6/7-9/10 slight.

Dorsal blood vessel: ?

Hearts: ?

Gizzard: ?

Calciferous glands: Sacs in 10 with lamellae continue along lateral walls, opening into oesophagus just in front of 10/11.

Intestine origin (caeca, typhlosole): ?

Nephridia: Holoic, bladders sausage-shaped.

Male organs: Testes/funnels in 10 and 11; seminal vesicles in 9-12.

Ovaries: 13.

Prostates: None.

Spermathecae: Two pairs in 10 and 11.

Gut contents: ?

Notes: Biparental; spermatophores often present on 35-30. Basic chromosome number is reported as n=17 and ploidy 2*n*=34. Its small size and relative rarity may cause under reporting of this taxon.

From "*The ESSEX NATURALIST being the JOURNAL (of proceedings) OF THE ESSEX FIELD CLUB."* Vol. iv. (2) of 1982, but possibly published in 1893, we now have Friend's description of synonyms:

"*The Celtic Worm (*Allolobophora celtica*, Rosa), like the preceding* [A. eiseni]*, has both a terrestrial and a dendrobaenic form. They differ so widely in appearance that I was for a good while unable to decide whether or not to regard them as distinct species. The form described by Rosa under this name is found in the soil. The tree- dweller (var*. rosea*, Friend) ought to be the type as representing the genus* Dendrobaena*. The prostomium or*

lip does not cut backwards into the first ring, as is the case with the foregoing. The setae are in eight rows. The ground form is of a violaceous colour on the back, whereas var. rosea *is a warm rosy brown. The male pores in Rosa's species are on papillae which affect the two adjoining segments by their size, whereas in the dendrobaenic form they are exactly like those of the other tree-frequenters. This is the sole distinguishing mark between the two forms*."

He then goes on to describe the papillae in 32 and 34 instead of the usual location on 33-34, – probably an error as his Fig. 2 and Table shows them on 33-34, and he remarks that it was not found in Essex, but occurs on old trees in Epping Forest. Typical laxity for our long lost 'friend' Friend.

Genus et species dubiae Lumbricidarum

After Vaillant (1899: 154), Michaelsen (1900: 517), Easton (1983) and Blakemore (2005, 2006, 2008).

Enterium Savigny, 1820: 100, 130 (corr. *Enterion* and laps. *Enterium* : Agassiz, 1846: 139) type-species: *E. terrestre* Savigny, 1820. Published in "*Description de l'Égypte* ...", after Savigny's expedition with Napoleon's Armée de l'Égypte, which is dated 1809 but considered published in 1822 by ICZN (Opinion 1461). Listed as *gen. dub*. in Michaelsen (1900: 517) and set aside after Sims (1973).

Enterion sp. Savigny, 1820 (= *Enterion terrestre* Savigny, 1820/2: 103) (err. non *Lumbricus terrestris* Linnaeus, 1758, nec Savigny, 1826: 180) listed as *sp. dub*. in Michaelsen (1900: 517).

Enterion opimum Savigny, 1826: 183 listed as a synonym (priority!) of *Octodrilus transpadanus* (Rosa, 1884), e.g. by Michaelsen (1900: 507) and Easton (1983).

Lumbricus apii Kinberg, 1867:100 described from Sausolita Bay, San Francisco forgotten after Michaelsen's (1900: 520) *species dubius* list; types in Leiden: 1939.

Hypogaeum hirtum Savigny, 1820 from Philadelphia, known only from original description.

Lumbricus argentinus Weyenbergh, 1879: 214 from Argentina.

Lumbricus armatus Kinberg, 1867: 99 from Argentina (Buenos Ayres).

Lumbricus azoricus Eisen, date? collected 1869 from Sao Miguel, Azores, in USNM.

Lumbricus castaneus Risso, 1826: 427 [non *Enterion castaneum* Savigny, 1826].

Lumbricus juliformis Baird, 1871: 96, from ? collected by the Antarctic Expedition.

Lumbricus guildingi Baird, 1871: 96, from St Vincent (possibly *Dichogaster sp.)*.

Lumbricus leptozonius Hagenbach, 1823 from Switzerland.

Lumbricus matutinus Weyenbergh, 1879: 215 from Argentina.

Lumbricus pampicola Kinberg, 1867: 99 from Montivideo, Uruguay. Type Leiden: 1934.

Lumbricus tellus Kinberg, 1867: 99 from Argentina (Buenos Ayres).

Lumbricus tahitana Kinberg, 1867: 99 from Tahiti.

Lumbricus vineti Kinberg, 1867: 99 from Madeira.

Many other names of dubious lumbricids are are freely provided in revisional databases of Lumbricidae etc. by Blakemore (2004, 2006, 2007, 2008); please quote and comment.

APPENDICES and REFERENCES

Consisting of conventions, abbreviations and descriptions of oligochaetological and general terms used in this text and as used by others (compiled from many sources including: Stephenson, 1930; Gates, 1972; and Sims & Gerard, 1985/1999).

A glossary of zoological terms is online here (Ref.).

Cladistic-jargon terms are modified from SASB and Palaeos websites: www.science.uts.edu.au/sasb/glossary.html and www.palaeos.com/Systematics/Cladistics/index.html.

See also classification glossary appended to Mayr & Bock (2002).

Conventions:

Taxonomic nomenclature follows The Code (see http://www.iczn.org/) such that Family and Genera names always start with a capital letter and Species names a lower-case letter; the genus name may be abbreviated. Optionally, the name(s) and publication date of the original author(s) follow the species name and go in braces where the genus has been changed (and the species name usually changes to agree in Latin gender of feminine, masculine or neutral). In synonymy lists, the authors of subsequent descriptions are denoted in this work by a colon or semicolon inserted before their citation, e.g. "*Lumbricus terrestris* **:** Blakemore, 1997: 1,5, fig. 1." Types are essential.

Two conventions are followed when describing earthworm regarding their segmental counts and setal designations. Firstly, segments are counted from the anterior starting from the peristomium (i.e., the segment with the mouth that usually lacks setae and bears the prostomium) using the normal and more familiar Arabic numerals thus avoiding confusion inherent in the use of Roman numerals in some earlier works. In answer to critics who, for some antiquated reason – or for no reason at all – insist on using Roman numerals; my defence of use of Arabic numerals has just one argument:- look to Michaelsen (1900)! Female pores are normally on 14, (male pores in megascolecids are usually on 18, and in lumbricids on 15), unless counts are reduced by suppression of anterior segments. Secondly, intersegments and furrows are designated by a slash (e.g. 1/2), variations are shown by a comma, and range by a dash (e.g. 3,4-5 meaning "*segments 3 or 4 to 5*"). When referring to the prostomium or to the range of the clitellum, ½, ¼ etc. indicate the extent of encroachment into a segment. Setae, counted from the ventral-most on each side, have lower case letters (e.g. a b c d) and in perichaetine species the dorsal-most setae are

designated z, the penultimate y, and so on; setal lines refer to longitudinal setal series, sometimes the width between pairs of setae are written without a space (e.g. ab lines, or the dd meridian). For lumbricine specimens setal ratios are often given with the distance between ab standardized to unity for comparison. Perichaetine specimens often have setal count ranges. However, there is no agreement between workers on which segments to make counts on and, due to intraspecific variation/preservation and methods of measurement, setal ratios are highly variable and of debatable taxonomic significance.

When surveying quantitatively, only count the anterior/head ends although the total biomass includes all portions and the results are expressed as per square metre (m^{-2}), regardless of depth. Cocoons can be counted separately (but included in biomass). Describing assemblages of mature and immature specimens, Gates (1972) gave formulations of the numbers of juvenile - aclitellate - clitellate – regressed, e.g. 1 - 1 - 1 - 1, in this case one of each; however this scheme did not include cocoons and often omitted the last group.

Abbreviations:

ACT, Australian Capital Territory (Canberra), Auststralia.

Auct., *auctorum*, meaning in the sense "*of authors*" subsequent to the original.

c. or ca., Latin *circa* - approximately.

Cf. or cf., Latin *confer* – compare.

Comb. nov., new combination (of a species in a genus).

CSIRO, Commonwealth Scientific and Industrial Research Organisation (Australia).

DPI, Department of Primary Industries (for Australian states).

e.g., abbreviation of Latin *exempli gratia* for "*for example*".

GM or gm, genital marking.

GS, genital setae.

i.e., Latin *id est* – meaning "*that is*," or "*that is to say*,".

lhs, left hand side.

m, mid as in mD = mid-dorsal, etc.

mL, mid-lateral.

mV, mid-ventral.

n.p., nephropore.

nr., "*near*" or cf. Cf.

NSW, New South Wales, Australia.

NT, the northern central tropical Australian province of Northern Territory.

NZ, New Zealand.

Part., partim L. *in* part.

Pp., pages.

Qld, Queensland a large state in northeastern Australia.

RJB, or R.J.B. - the author, R. J. Blakemore.

rhs, right hand side

RS, research station.

s. lat., *sensu lato*, description "*in the wide sense*".

sensu, Latin – meaning "*in the sense of*".

Sp., species (singular); Spp., species (plural).

s. str., *sensu stricto*, description "*in the strict sense*", often meaning restricted.

SA, the state of South Australia.

Sp.p., spermathecal pore.

Syn., syns., synonymous, synonymies.

Syn. nov., new synonym.

Tas., Tasmania the southeastern Australian Island state.

TP, tuberculum pubertatis or tubercula pubertatis.

U, circumference, from the German 'Umfang'.

V, ventral.

Vict., Victoria a mainland state in southeastern Australia.

Viz., L. *videlicet* – meaning "*that is*," "*namely*," or "*to wit*,".

WA, the huge state of Western Australia.

Glossary of Definitions:

Note: Patterns of morphological organization are characterized as "*Acanthodriline*", "*lumbricine*", "*microscolecine*", etc. and the adjective designating pattern was distinguished from that for a subfamily by omission of the final vowel by Gates (1959: 236 footnote) but for consistency and euphony I prefer to retain the final adjectival 'e'.

Aborted, vestigial and functionless, or lacking and having become so during development of species/specimen.

Acanthodriline (or Acanthodrilin) - in the Classical System, having prostatic pores in 17 and 19, separate from male pores in 18 (or their homoeotic equivalents). These pores are often in seminal furrows (= longitudinal grooves) between eq/17 and eq/19. (Fig.). Cf. Megascolecine.

Acinus (*pl.* acini), acinous, a sac-like termination of a branched gland.

Aclitellate, without a clitellum, often adult or nearly so but underdeveloped or regressed.

Adiverticulate, without diverticula, usually referring to spermathecae but also to nephridia.

Adventitious, accidental, occurring in an unusual habitat or host.

Aestivation, a period of inactivity, or dormancy, resulting from unfavourable summer (moisture) conditions when a worm coils up in a cell often at depth in the soil.

Afferent, supplying (blood) to an organ.

Agiceriate, gizzardless, without a gizzard; cf. monogiceriate, digiceriate, etc.

Allochthonous, exogenous, non-native to an area, *cf.* autochthonous.

Amphigony, see amphimictic.

Amphimictic, amphimixis, reproduction involving fertilization of the ovum by sperm. In megadriles, with the connotation of biparental, *cf.* parthenogenetic.

Ampulla (*pl.* ampullae), distended ental portion of an adiverticulate spermatheca in which spermatozoa are stored temporarily or the widened ental portion of the main axis of a diverticulate spermatheca and then without such a storage function. Also, when qualified by dorsal or primary, referring to a distal constricted-off portion of a seminal vesicle.

Anandric, anandry, without testes.

An-arsenosomphic - lacking male pores, as in (R type) parthenogenetic morphs, regenerates or abnormal specimens.

Anastomosis, cross connections of ducts, branches of organs, or, more usually, of blood vessels.

Andry, referring to testis containing segments.

Anecic (French anéciques from Greek *anekas* = upward reaching), in Bouché's, 1977, classification, perhaps partially equivalent to Lee's prior (1959: 419; 1985) deep-burrowing worms that feed on dead leaves on the surface, *cf.* topsoil, litter dwellers, endogean, epigean.

Anisochaetine ("*with uneven setae*" - an adjectival term introduced by Blakemore, at the Vermillennium conference held in Kalamazoo, Michigan, September 16-22, 2000) for a non-lumbricine or perichaetine state where the setal counts vary in different parts of the body, e.g., often increasing from 8 anteriorly to >8 posteriorly as in type of genus *Anisochaeta*.

Anlage, in embryology = primordium; in genetics = gene or allele.

Annular, of clitella, encircling the body, *cf.* saddle-shaped.

Annulus (*pl.* annuli) or annulation(s), ring formed by a superficial secondary furrow around a segment, commonly two or three superficial rings also present (biannulate or triannulate).

Anthropochorous, anthropochore, transported by man, usually unintentionally *cf.* peregrine.

Aortic arch, see hearts.

Apomorphic, apomorphy, a specialized character or structure that is derived (evolutionarily recent) *cf.* plesiomorphic.

Arsenosomphic, with male terminalia (cf. an-arsenomrphic).

Asetal, without setae. *cf.* peristomium, periproct.

Astomate, with reference to nephridia, "closed", without a nephrostome.

Atrial, glandular tissue associated with a cleft or coelomic invagination containing the male pore (e.g. in Moniligastridae or Lumbricidae).

Atrium (*pl.* atria), a diverticulum of a spermathecae in two moniligastrid genera: *Drawida* and *Moniligaster*. (In earlier works may refer to a prostate).

Atrophy, diminuation in size or function of an organ.

Atyphlosolate, without a typhlosole.

Autapomorphy, an apomorphy (i.e., a novel character) that is restricted to a single species and so cannot provide information about the phylogenetic relations of that species other than the degree of its divergence from its nearest relatives. Cf. synapomorphy.

Autochthonous, native, indigenous, *cf.* allochthonous.

Autogamy (= autofecundity), self-fertilization in hermaphrodites.

Autotomy, automize, self-amputation, in megadriles the process of breaking off a portion of the posterior/tail to avoid predation or attack; possibly by autolysis – the destruction of cells of the body by its own serum or enzymes. See also coelomic fluid defence.

Avesiculate, without seminal vesicles when referring to genital systems, without a bladder when referring to nephridia.

Balantin(e), with male and prostatic pores in 19.

Bidiverticulate, with two diverticula (to a spermatheca).

Bigiceriate (= digastrid), with two gizzards.

Biparental, true sexual reproduction involving exchange of sperm and union of gametes between two specimens (cf. amphimictic, parthenogenetic).

Biprostatic, with two prostates.

Biramous, two branched.

Bithecal, with two spermathecae.

Blood glands, follicles clustered in the pharyngeal region, sometimes into racemose aggregates, supposed to function in the production of haemoglobin and blood corpuscles (see Stephenson, 1924).

Brain, see cerebral ganglion.

Brown bodies, spheroidal, ellipsoidal or discoidal bodies, free in the coelomic cavity, filled with corpuscles, setal debris and foreign bodies of various sorts such as cysts of parasites, nematodes and their ova.

Buccal cavity, the first region of the alimentary canal, between mouth and pharynx.

Caecum (*pl.* caeca), a blind diverticulum or pouch from the alimentary canal that probably functions for culture of symbiotic gut flora and fauna. (In earlier works, sometimes refering to the spermathecal diverticulum). Intestinal caeca are single or paired, and may be in series; the two main forms are simple (smooth walled but sometimes with surface lobulations) and manicate (composed of several secondary lobes like fingers of a glove).

Calciferous gland (= 'Glands of Morren'), strictly a whitish gland that secretes calcium carbonate and opens into the gut via an oesophageal pouch, often used for similar organs of unknown function such as the Ocnerodrile diverticula.

Canaliculate, longitudinally grooved.

Capsule, see cocoon.

Casts, or castings, the voided earth and other waste matter that are commonly deposited following passage through the gut. Not all species form their casts above the ground.

Caudal, of the tail region.

Cephalization, loss of metameric uniformity at anterior end of body involving some or all of the following; abortion of septa beginning with 1/2, of nephridia and setal follicles beginning with 2, of segmental hearts or connectives between dorsal and ventral blood vessels. Sometimes involving total or almost total abortion of one or more segments.

Cerebral ganglia (*sing.* ganglion), concentrated, supra-oesophageal, paired nerve cells that function as a simple brain.

Chaeta, (*pl.* chaetae), see seta.

Chitin, resistant aminopolysaccaride composing setae of oligochaetes and integument of insects.

Chloragogen cells, whitish or yellow fatty cells formed around the alimentary canal; their function is uncertain but is attributed to excretion and regeneration in the literature. Often accumulate in the posterior.

Chorology (from Greek *khoros* - place), study of causal relationships between geographical phenomena, such as climate or altitude, and study of the spatial distribution of organisms within a region.

Chthonic, Greek for living "in, under, or beneath the earth".

Cingulum, see clitellum.

Circumpharyngeal connective, nerve collar, between cerebral ganglion and ventral nerve ganglion.

Classical, of or pertaining to the "classical system" of the Oligochaeta (see next definition).

Classical System, the classification of the Oligochaeta as initially presented in Vol. 10 of *Das Tierreich* by Michaelsen (1900) and expressed in its final form by Stephenson (1930) in *The Oligochaeta*. This system held that genital systems are more conservative over evolutionary time than are somatic characters and crystallized around two suppositions (from Gates, 1972): (1) Genera, even subfamilies and families, can be defined and arranged in straight-line phylogenetic sequences by a very few characters such as lumbricine and perichaetine, micronephric and meganephric, presence or absence of gizzard or calciferous glands. (2) Other somatic structures of the digestive and excretory as well as the vascular and nervous system, are phylogenetically less important. Gates revised this system from studies of individual, anomalous, and

regenerative variation, as well as of genital and geographic polymorphism, he intorduced greater emphasis than previously on somatic characters. However, the Classical System still provides structural stability and a practical framework for all subsequent revisions, and its strengths also lie in its 'convenience' and practicality, as well as its apparent phylogenetic validity. Many subfamilies are now raised to family level status.

Classification, as stated by Mayr (1998), is "*an information storage and retrieval system. Its aim is to permit you to locate an item with a minimum of effort and loss of time*". [Many taxonomists yet seem to have little consideration of this basic aim].

Clitellate, having a clitellum, the age or stage during which the worm has a clitellum, *cf.* aclitellate.

Clitellum, [L. *clitellae* – pack saddle], a regional epidermal swelling where gland cells secrete material to form the cocoon (and, in most groups, to provide nourishment for the encapsulated embryos). Often called the "collar". There are two recognised types: annular clitellum or cingulum, which encircles the body; and saddle-shaped where a clitellum encompasses only the dorsal and lateral parts of the body. The segmental extent (and range) of the clitellum is of systematic value although precise characterization is sometimes a function of preservation and observer's choice.

Cocoon, egg-case (oöphore) secreted at the clitellum, shed and containing several eggs, not all of which emerge. Often termed 'capsule'.

Coelom, the fluid-filled body cavity between the body wall and the alimentary canal.

Coelomic fluid, complex of proteins, enzymes and coelomocytes in solution in the body cavity of earthworms, also know to comprise immunoactive cells and molecules involved in immune defence; separate from the blood vascular system.

Coelomic fluid defence, the ejection of coelomic fluid, usually from the dorsal pores or other orifices, in response to stress or attack. The "Blue Squirter Worm", *Didymogaster sylvatica* Fletcher, 1887, can exude fluid for several centimeters (Blakemore, 2001).

Coelomocytes are autonomous cells in the coelomic fluid, primarily: (1) autofluorescent eleocytes/chloragocytes filled with numerous large granules (chloragosomes); and (2) amoebocytes; they have been categorized into four classes as lymphocytic coelomocytes, granulocytic coelomocytes, eleocytes (chloragogen cells), and inclusion-containing coelomocytes. Large granules may form to encapsulate shed setae or nematodes. Details here – Ref.

Collar, see clitellum.

Commissurals, usually paired lateral blood vessels connecting dorsal and ventral, or posteriorly the sub-neural, vessels (cf. latero-oesophageal hearts).

Composite, with reference to certain stalked glands, each of which comprises several similar units.

Compressed, flattened laterally, *cf.* depressed.

Concopulant, a mating partner.

Congeneric, of congeners, belonging to the same genera.

Congeries, an assemblage (of species).

Copulatory setae, those in the same segment as or near the spermathecae. Occasionally refers to similar setae in an adjacent but athecal segment (*cf.* genital and penial setae).

Copulatory pouches, invagination of the male pores; also = spermathecae in some older publications, see also copulatory chamber.

Copulatory chamber, an invagination, containing the male pore, that reaches through the body wall into the coelom; may contain a penis, setae, papillae, and have associated internal glands. Also 'bourses copulatrices' in some publications prior to 1900. The preferred nomenclature is now “copulatory pouch”

Cosmopolitan (Gk, kosmos, world; polites, citizen), ecological meanings are:

1. found in every country
2. widely or globally distributed – this is closest to the present interpretation
3. present in more than one country

Crop, a widened portion of the digestive system that lacks the muscularity of a gizzard. In the Lumbricidae, found at the beginning of the intestine and in front of the gizzard (see proventriculus).

Cuticle, a thin tough, non-cellular transparent outer layer of the body wall (see iridescence).

Cysticercoid, larval stages of the cestode (tapeworm).

Decathecal, with ten spermathecae, usually in five pairs.

Definitive, capable of being used in definition of a taxon.

Depressed, flattened dorso-ventrally, *cf.* compressed.

Diagnostic, uniquely characterizing a taxon (see precis).

Diapause, a state in which gut is empty and the worm is often tightly coiled in a closed-off soil cell as in aestivation. Two states have been characterized: *obligatory*, internally controlled for rest or repair, and *facultative* in response to environmental factors. In either case activity, does not re-commence until certain physiological events have been completed, *cf.* quiescence.

Diaphanous, transparent, pellucid.

Digitiform, finger-shaped.

Dimorphic, a species with two genetically determined morphs.

Diploid, having double set of homologous chromosomes (cf. haploid, polyploid).

Distal, away from place of attachment, as in regenerate, or an organ on a septum, the gut, or body wall, *cf.* proximal.

Diverticulum (*pl.* diverticula), diverticulate, having an outgrowth of some sort from the main axis of an organ (e.g. on a spermatheca).

Dorsal vessel, a major blood vessel located above the dorsal surface of the alimentary canal conducting blood anteriorly.

Dorsal pore, small sphinctered intersegmental apertures in the mid-dorsal line leading to the coelomic cavity.

Drilosphere, the region of soil around earthworm burrows.

Duodecathecal, having 12 spermathecae, usually in six pairs.

Ecology (from Greek oîkos, "*house*"; -λογία, -logia, study of) is the comprehensive and 'multidisciplinary' science of the relationship between organisms and their natural environment including the distribution and abundance of life. Thus, in my wider view, all other biological sciences are subordinate to Ecology. Also in the current author's view, dead, fossilized or biological products should also be considered as within the sphere of Ecology such that apparently lifeless forms like carrion, logs, flint, coal, oil and biogenic iron, silica and calcium carbonate are ecological, as are the various applications of these products.

Eco-taxonomy or Ecological-taxonomy, here implying a combination of good ecological survey with competent taxonomic identification; including details of the species' associations, its behaviours, life-cycle, and its external and internal habitat (of pathogens and parasites) to represent the species in its complexity and its entirety. Concomitant with this is the need for eco-taxonomists to collect the speimens they describe in order to judge their habitat and associations, i.e. field ecology combined with laborious taxonomy.

Ectal, ectally, outermost or nearest to the body wall, *cf.* ental.

Egg sac, see ovisac.

Endemic, indigenous or restricted to a region, *cf.* allochthonous.

Endogean, endogées, [from Greek *endon*, within; *gaia*, the earth], Bouché's (1977) classification of worms that live and feed in the mineral soil at or below the root mat [equivalent to Lee's prior (1959: 419; 1985) “sub-surface feeders”]. See topsoil dwellers.

Ental, entally, away from the body wall, towards the centre of the body, *cf.* ectal.

Enteroic, when referring to the excretory system, opening into gut lumen, *cf.* exoic.

Enterosegmental organs, paired, segmentally repeated structures of unknown function closed to mD on dorsal face of the post-gizzard gut in moniligastrids.

Entonephric, see enteroic.

Epidermis, the outer cellular layer of the body wall, which secretes a protective cuticle.

Epigean, epigaen, epigeic, epigenous, epigées, [from Greek *epi,* upon; *gaia,* earth] classification of plants and animals that Bouché (1977) extended to worms that live upon the soil surface or “litter dwellers” as per Lee’s prior (1959) system. See endogean, hypogean.

Epilobous, epilobic, referring to a prostomium that is continued by a tongue into the peristomium but without reaching 1/2.

Epimorphic, epimorphosis, regeneration that results in addition of new tissue at the level of amputation.

Equator, a central meridian of latitude of a segment often or usually equivalent to a circumferential line passing across apertures of setal follicles.

Equatorial, at, of or pertaining to a central meridian of latitude in a segment.

Equimeric, equimery, with reference to regenerates, having the same number of segments as had been amputated, the state of being such.

Esophageal, American for oesophageal.

Euramerica, the continent formed in the late Mesozoic before the opening of the north Atlantic, comprising part of Laurasia (between Mid-continental Seaway of east North America and the Turgai Straits separating Europe from Asia).

Euryhaline, tolerant of salinity gradients.

Euryoecious, having a wide range of habitat tolerance.

Eurytopic or eurytipicity, displaying wide tolerance for a range of habitats.

Evaginate, evagination, to grow out from, an outgrowth of, as calciferous sacs of the lumbricid oesophagus.

Exogenous, allochthonous, *cf.* endogenous, autochthonous.

Exoic, when referring to the excretory system, opening to the exterior through the epidermis, *cf.* enteroic.

Exonephric, see exoic.

Exotic, imported, foreign, alien, in contrast to native, endemic, and autochthonous.

Extra-mural, of calciferous glands: located externally on oesophagus, commonly stalked.

Exxidine - adjectival term for species having acanthodriline male pores arrangement with non-tubular prostates as in Exxidae genus *Exxus*; or with characteristics of a member of the family Exxidae (*cf*. acanthodriline, megascolecine, etc.).

Facultative, contingent, having the power to live under different conditions. *cf.* obligatory.

Family, a taxon usually comprising a number of genera, with a name ending in –idae (*cf.* Sub-family, –inae).

Female pores, external apertures of the female ducts; single or paired, often minute and for most families and specimens (unless aberrant) found on segment 14.

Female funnel, enlargement of ental end of an oviduct to facilitate entry of ova on their way to the exterior.

Female ducts, female gonoducts. See oviducts.

Fimbriated funnel, with a filamentous fringe to facilitate the entry of sperm or ova.

Fissure, an epidermal crevice containing, discrete male and prostatic pores, as well as apertures of penisetal follicles.

Furrow, external groove around the body between segments.

Genital setae, setae associated with genital markings – see seta.

Genital tumescences, in the Lumbricidae, areas of modified epidermis without distinct boundaries and through which follicles of genital setae open.

Genital markings, distinct epidermal areas that are variously circular or pad-like, glandular swellings, pits or grooves. Involved in mate recognition and the alignment, charging and (successive) co-location of reproductive apertures especially spermathecae. Of systematic importance. (See genital tumescences).

Genotype, a term not recognized by the ICZN Code, formerly used for type species, but that should not now be used in zoological nomenclature [Recommendation 67A].

Geophagous, feeding on soil *cf.* detritivor, saprophore.

Giceriate, having one or more gizzards.

Girdle, see clitellum.

Gizzard, the muscularized portion of the digestive system, in Lumbricidae, anterior to the intestine and posterior to the crop. Duplicated in some groups and reduced in others.

Gabrous, devoid of setae or 'smooth'.

Gonad, gonadal, a testis, ovary, or an organ simultaneously or consecutively producing sperm and ova. Of or pertaining to a gonad.

Gondwanaland, the huge Mesozoic southern continent separated by the epicontinental Tethys Sea from the northern continent of Laurasia after the separation of the united Palaeozoic continent of Pangaea. At end of Triassic, West Gondwana (comprised South America and Africa plus Madagascar) separated from East Gondwana (comprised of Antarctica, Australasia and a then detached Peninsular India).

Gonoducts, male, female, ducts or passages that carry gametes from the coelomic funnels to or towards the exterior. (*cf.* Sperm ducts, oviducts.)

Gonophore, see male pores, female pores.

-gyny, the characterization of ovarian location along the main axis, *cf.* holo-, meta- and pro-gyny.

Haemerophilic, not averse to culture nor some human interference with the environment.

Haemerophobic, averse to culture and human interference with the environment.

Haemoglobin, respiratory protein, in solution in the blood serum of earthworms.

Haploid, having a single set of chromosomes (cf. diploid, polyploid).

Hatchling, small worm that emerges from a cocoon.

Hearts, enlarged, segmental pulsating connectives in an anterior region of the body between the ventral and one or both other longitudinal trunks, the dorsal and supra-oesophageal. According to the some terminology those opening into the dorsal trunk are lateral, into the supra-oesophageal are oesophageal, into both are latero-oesophageal.

Hemerobiont, dependent on human culture (cf. hererodiaphores, hemerophiles, hemerophobes – terms derived from studies of Swedish worms by Julin (1949)].

Hemerodiaphore, a species indifferent to the influence of human culture.

Hemerophile, a species favoured by human culture.

Hemerophobe, a species aversely affected by the influence of human culture.

Hermaphrodite, having both male and female reproductive organs.

Hepato-pancreatic glands reported by Bahl & Lal (1933) in *Eutyphoeus* produce enzymes but may also function to culture microbes (as with intestinal caeca).

Heterodynamous, development indirect because interrupted by a period of rest called diapause.

Heteromorphic, with reference to regenerates, a head regenerated instead of a tail or a tail instead of an amputated head.

Hibernation, the state of rest or inactivity during unfavourable winter conditions.

Hibernestivation, the state of rest or inactivity during unfavourable conditions in the monsoon tropics that extend through both cool and hot seasons.

Holandric, holandry, classical terms that mean testes restricted to 10 and 11, or a homoeotic equivalent, *cf.* proandry, metandry.

Holarctic region, a zoogeographical region comprising the Palaearctic and Nearctic regions.

Hologynous, hologyny, classical terms that mean ovaries restricted to 12 and 13 or a homoeotic equivalent.

Holoic, referring to an excretory system, having a single pair of large, stomate, exoic nephridia in each segment of the body except the first few and last one; referring to a nephridium, having a preseptal nephrostome or funnel opening into the coelomic cavity, a post-setal looped tubule opening to the exterior through a single epidermal nephropore and derived without fragmentation from a single embryonic rudiment. *Cf.* meroic. Note that the terms 'macroic' and 'microic' are substituted for holoic and meroic in some recent treatments. See also 'nephridium', 'tufted nephridia'. [Nephridial terminology follows Gates (1972: 320) who avoided unnecessarily long terms such as 'holonephridial' and 'meronephric' that have the same meaning as holoic and meroic, thus avoiding tautologies or ridiculously convoluted phrases such as "*megameronephridial nephridia*" or "*Nephridia: micromeronephridia median to mega-meronephridia*"; these simpler terms are also used in wider invertebrate morphology dictionaries, e.g. http://digitalcommons.unl.edu/onlinedictinvertzoology/2/].

Holonephric, holonephridial, obsolete and tautological terms (e.g. "nephridia holonephridial"). *Cf.* holoic, meroic and see 'nephridium'.

Holotype, the single lodged specimen that distinguishes and represents a species.

Homodynamous, development direct, ie., not interrupted by a diapause.

Homoeosis, presence of an organ, or pairs of organs, or a series of organs, in a segment or series of segments, other than that or those, in which usually or normally found, similarly for secretory pores (e.g. female pores in 13 or 15 rather than 14). Reference primarily is to intraspecific variation, secondarily to phylogenetic variation, for a species

or genus may be homoeotic with reference to related species or genera. In case of individual homoeosis, the dislocation may involve one or both organs of a segmental pair. The former is asymmetrical, the latter symmetrical homoeosis.

Homoeotic, the condition of having glands or organs in a segment(s) where they do not normally occur. Refers principally to intraspecific variation (see homoeosis).

Homology, homologous, similarity due to common evolutionary origin. Cf. homoplasy.

Homomorphic, of regenerates, of the same cephalic or caudal nature as the part that was amputated.

Homonym, each of two more available specific or subspecific names having the same spelling but applied to different taxa, (usually the earliest name takes priority).

Homoplasy, homoplastic, homoplasious, similarity dur to independent evolutionary change in mostly unrelated groups (e.g. wings of birds, bats, or insects are all homplastic). Cf. homology.

Hoplochaetellin(e), of male terminalia in which one pair of sperm ducts open together with the prostatic ducts of 17 (or close to the prostatic pores), usually with another pair of sperm ducts similarly associated with the prostates of 19 (or in both 17/18 and 18/19).

Hyperandric, hyperandry, having testes additional to those of 10-11.

Hypergynous, hypergyny, having ovaries additional to those of 12-13.

Hypermeric, hypermery, of regenerates, having more segments than had been removed prior to the regeneration.

Hyperplasia, hyperplasic, in oligochaetes, having more than the usual number of organs in a set or battery.

Hypogean, hypogaen [from Greek *hypo,* under; *gaia,* the earth], living in the soil; endogean (perhaps usually applied to entomolgical species that inhabit soil).

Hypomeric, hypomery, of regenerates, with fewer segments than had been removed.

Immature, a young worm, with undeveloped clitellum and sexual organs (often termed adolescent).

Indigenous, native, belonging to a locality, not imported, *cf.* endemic, exotic.

Intersegmental groove, a circumferential depression of strongly contracted specimens that contains the intersegmental furrow. A common failure, in classical writings, to distinguish between groove and furrow resulted in lack of precision with reference to systematically useful characterizations.

Intersegmental furrow, the boundary between two consecutive segments, almost in a geometrical sense, but actually the level at which the epidermis is thinnest and where

colour is lacking in pigmented species.

Intestinal glands (glycogenic organs of Beddard, 1890: 61) or supra-intestinal glands are found in some families/genera, their function is obscure but they are sometimes described are being analogous or complementary to oesophageal calciferous glands and of having a relationship with the (termination of) the typhlosole (e.g. Bahl & Lal, 1933). It is further possible that some intestinal glands have similar function to the intestinal caeca. Smaller paired sacs often seen intraseptally on the dorsal blood vessel may relate to immunity or purification of the blood, but this is presently unresearched – see "Lymph glands".

Intra-mural calciferous glands, occurring within the oesophageal wall (in Lumbricidae and some other families, e.g. Eutyphoeus of the Octochaetidae).

Invaginations, an ingrowth, as of the epidermis into the parietes, or of the whole body wall into the coelom.

Iridescence, in the context of earthworm biology refers to 1) the shining white diffraction of light from the aligned tails of sperms aggregated on the male funnels (*q.v.*) and/or spermathecae (in the ampulla or diverticulum), or 2) the appearance of multiple shimmering colours as a result of light refracted from the cuticle.

Juvenile, referring to young from time of hatching till appearance of seminal furrows or grooves, genital tumescences, markings and/or pores, see immature.

Lamella, (*pl.* lamellae) any thin plate-like or scale-like structure.

Lateral, on, of, or pertaining to the sides of a body or of an organ but in connection with the vascular system, a heart joining the ventral trunk below the gut and the dorsal blood vessel above the gut. Also any segmental commissure with the same relationship to the two major trunks.

Latero-oesophageal, with reference to the vascular system, a heart or other vessel joining the ventral trunk below the gut but bifurcating above the gut, with one branch to the supra-oesophageal trunk, the other to the dorsal trunk.

Laurasia, the huge Mesozoic northern continent (see Gondwanaland); marine incursions during Jurassic isolated eastern North America and Europe from western North America and Asia although northern land connections linked each side of North America to the other landmasses to form Euramerica and Asiamerica.

Limicolous, dwelling in mud.

Limiphagous, mud-eating.

Limnicolous, living in lakes.

Littoral, living on seashore.

Lumbricid, a member of the Holarctic family Lumbricidae common in northern

temperate regions.

Lumbricin(e), having 8 setae per segment usually in 4 pairs, *cf.* anisochaetine, perichaetine.

Lumen, the cavity of a duct, sac, gland or of the gut.

Lymph glands, small organs on the anterior faces of septa and associated with the dorsal blood vessel, in the intestinal regions of pheretimoids and other megascolecids such as *Lennogaster*, supposedly functioning in production of phagocytes/amoebocytes.

Macroic, large, with reference to excretory organs, a substitute for the classical meganephridium (cf. tufted nephridia).

Macrolecithal, of eggs with large yolks, *cf.* microlecithal.

Male pores, primarily openings to the exterior of the male ducts (usually on segment 18 for megascolecids and 15 for lumbricids). The pores may be superficial, be invaginated into (eversible/penial) chambers confined to the parietes or reaching more or less extensively into the coelomic cavities, or the apertures of such chambers may be withdrawn into a depression that can be closed off by apposition of its margins. Union of male and prostatic ducts also introduces other complications, ie., the ducts may unite just beneath the epidermis, deeper within the body wall, or within a chamber invaginated into the coelom which may or may not have a penis or some sort of porophore in which case male and prostatic pores may still be discrete. Although of great importance to taxonomy, these pores are often minute and only traceable during dissection. In certain species, particularly of the Lumbricidae and Eudrilidae and in some megascolecids, the pores are large and more readily discernible. Some other species have parthenogenic morphs without male pores.

Male ducts, male gonoducts. See sperm ducts.

Male funnel, a funnel or rosette-shaped enlargement of ental end of a sperm duct, with central aperture through which sperm pass into lumen of the duct on their way to the exterior. Sperm, prior to entering the ducts in many species, temporarily aggregate on the funnels in such a way as to reveal their presence by iridescence.

Manicate, hand-shaped, usually referring to intestinal caecum of certain pheretimoids in which the organ comprises several anteriorly directed secondary caeca.

Megascolecina, (Order or Superfamily?) from Michaelsen (1924) comprising Acanthodrilidae and Megascoecidae at least.

Megadrili* Benham, 1890: 218, i.e., the **megadriles** corresponding to the 'Earthworms', having a capillary network of blood-vessels on the nephridium, and this is very likely due to the difference in size and to the character of the medium in which this group lives [presumably not detectable in wholly meroic species]. Characters nearly constant in the Megadrili in which "*earthworms*" differ from Microdrili "*water-worms*" according to Benham (1890) are:

Large size, varying from a few cm to more than 3m; thick, pigmented, and

opaque body-wall, though the pigment may be absent and the wall more of less transparent on the ventral surface.

Prostomium separated by a groove from the peristomium (mostly).

Setae not arranged in groups (bundles); when they are so arranged there are never more than two setae in a group (?*Echinodrilus* Vaillant). Setae are nearly always simple, or the modification when present takes a different direction from that of the Microdrili.

The clitellum varies in position with regards to the male pores, and **always occupies more than two somites** [this bolding, by me, perhaps provides the single most commonly definitive character although some 'microdriles' rarely show this character].

A gizzard [or more than one gizzard] is nearly always present, except in such cases as "*Criodrilus, Pontodrilus, Microscolex,* and *Photodrilus*", where the character of the food renders it useless [possibly atrophied secondarily].

With the exception of a few genera, nephridia occur in all somites after the third or fourth, including the genital somites [absent in 10 in some Moniligastridae].

The Megadrili included Plectonephrica [= meroic families, now defunct]: Typhoeidae, Acanthodrilidae, Perichaetidae, Moniligastridae, Eudrilidae, Perionycidae, Geoscolecidae, Rhinodrilidae, Lumbricidae; all 9 families as defined in Benham (1890).

For a summary of higher classification, especially of the boundary and useage of Megadrili, see Beddard (1895: 157; 1896 but include the Moniligastridae), Gates (1962: 299; 1972: 28) and *vide supra*.

Other characters of differentiation are given under Microdrili Benham, 1890: 218 below.

***NOTE:** Under ICZN the terminations of names above Superfamily are ungoverned although Easton (1981) uses Order **Megadrilacea** for the Megadrili or megadrile worms. Gates (1945: 395) used the terms Microdrili and Megadrili to refer loosely to families Aeolosomatidiae to Haplotaxidae or Alluroididae and Moniligastridae to Lumbricidae respectively (*vide* Stephenson, 1930: 721).

Meganephridium (*pl.* meganephridia), meganephridial, one of a pair of large excretory organs, in the classical system often referring to organs now called holonephridia.

Megascolecid, of or pertaining to worms or taxa of the family Megascolecidae.

Megascolecine, in the classical system, indicating that the single pair of prostates, tubular or racemose, opened to the exterior in 18 together with the sperm ducts. Supposedly arising by deletion of prostates of 17 and dislocation into 18 of prostates from 19. (Fig.). Cf. Acanthodriline.

Megascolicoid, cf. Megascolecid, of or pertaining to worms or taxa of the classical family Megascolecidae.

Meroic, divided, with reference to the excretory system, often minute nephridial tubules formed by longitudinal or transverse fragmentation of the original single pair of embryonic rudiments of each segment. When parietal, often numerous and then said to be "*in forests*" almost covering the body wall, *cf.* holoic (see also tufted nephridia). Meroic herein means any increase or derivation from the holoic state. See also: holoic; 'nephridium' and http://digitalcommons.unl.edu/onlinedictinvertzoology/2/.

Meronephric, meronephridial, obsolete and tautological terms (e.g. "nephridia meronephridial"); cf. meroic, holoic and see 'nephridium'.

Meronephridium (*pl.* -a) one of many small nephridia.

Mesial, in the middle of the vertical or longitudinal plane.

Metagynous, metagyny, classical terms now meaning only, ovaries restricted to 13 or a homoeotic equivalent, the state of being such.

Metamere, a segment.

Metameric, pertaining to segmentation.

Metandric, metandry, (meroandry) classical terms now meaning only, a single pair of testes restricted to 11, the state of being such, *cf.* holandry, proandry.

Microdrili Benham, 1890: 218, i.e., the **microdriles** corresponding to the "*water-worms*", lacking a capillary network of blood-vessels on the [holoic] nephridium. Other characters of Microdili that are rarely present in the Megadrili are:

Generally smaller size, and thin, transparent body-wall.

Prostomium not separated from the peristomium by a groove.

Setae always in four groups (bundles) per somite, and usually more than two in each group: frequently the setae are of two sorts in each somite, and may be capillary, uncinate, forked, or simple.

The clitellum is always developed round the male pores, and generally occupies only two simites.

There are no nephridia in the genital somites. There is no true gizzard, no typhlosole, no subneural vessel. [There last four negative characters, however, may hold trued for some 'earthworms'].

The Microdrili included Vejdovsky's families Discodrilidae, Enchytraeidae, Tubificidae, Phreoryctidae, and Lumbriculidae. Cf. Megadrili families above. Note that Gates (1972: 28) says the remaining unique character of the Microdriles relates to their reduce vascular system such as lack of subneural trunks and of lateroparietal trunks also and possibly lack of three pairs of nerves per segment as found in the Megadrili.

Microic, smaller than macroic, substituting for the classical micronephridial, a term often applied to nephridia smaller than meganephridia.

Microlecithal, eggs with small amount of yolk requiring embryo to obtain nourishment from material in cocoon.

Micromeronephridium (*pl.* -a) minute meronephridium.

Micronephridium (*pl.* -a) in classical systematics often with meaning of meronephridium *ie.* small nephridium.

Microscolecin(e), in classical terminology, provided with a pair of the tubular prostates opening to the exterior in 17 along side or together with the sperm ducts.

Moniliform, arranged like a string of beads.

Monophyletic, (or Monophylic) with a single common ancestry.

Monophyletic taxon, also called a clade, is the building block of cladistics referring to a group of organisms including their most recent common ancestor and all the descendants of that common ancestor. E.g. Insecta, vertebrates, Mammalia, angiosperms, etc.

Monothecal, having only one spermatheca.

Monotypy, the situation arising when a genus-group taxon is established with only one originally included species; or when a family-group taxon is established with only one originally included genus.

Morph, a group of individuals that share a common anatomy resulting from degradation, deletions, or other changes from structure of the ancestral amphimictic population cause by reproductive isolation. Such isolation usually comes about as a result of parthenogenesis.

Morphallatic, morphallaxis, a regenerative process in which the new parts are reorganised from the old *in situ* instead of being formed anterior or posterior to the level of amputation.

Morren's gland, see calciferous gland.

Mouth cavity, see buccal cavity.

Mouth, the anterior opening to the alimentary canal located in the peristomium.

Muscular tube, see nephridial bladder.

Nearctic, a zoogeographic region comprising Greenland, North America and northern Mexico.

Neotropical, a zoogeographic region encompassing South and Central America south of Mexican plateau and the Caribbean.

Neotype, a single specimen designated as *the* type specimen of a nominal species-group taxon of which the holotype (or lectotype), and all paratypes or all syntypes are lost or destroyed. Neotypification is the act of selecting a neotype. (Nominal taxon, see taxon).

Nephridial reservoir, see nephridial bladder.

Nephridial bladder, the extended portion of the nephridial tube connected to the nephropore (see vesiculate).

Nephridial pore, see nephropore.

Nephridiopore, see nephropore.

Nephridium (*pl.* nephridia or "small kidneys"), the organ for nitrogenous excretion (holonephridium or meronephridium). Apart from tufted nephridia, there are just two forms of nephridia (after Michaelsen, 1907 and Blakemore, 2000): holoic as found in the 'primitive' families and genera, and non-holoic for any derivation at all from holoic.

Nephropore, the external opening of the nephridium.

Nephrostome, the ciliate funnel at the ental end of the (holo)nephridium.

Obligatory, limited to the one mode of life or action, *cf.* facultative.

Octoprostatic, having 8 prostates.

Octothecal, having 8 spermathecae.

Oesophagus, the portion of the gut between the pharynx (anterior) and crop or intestine (posterior), ending in the oesophageal valve. When referring to the circulatory system, a heart that opens dorsally into the supra-esophageal trunk and beneath the gut into the ventral trunk.

Omnivorous, omnivore, non-selective feeder.

Ontogenetic, ontogeny, having to do with individual development.

Oöcyte, a diploid cell that produces haploid eggs (ova) by meiosis.

Oöphore, egg case or cocoon.

Organic Agriculture or Natural Farming, a good introductory summary is here.

Oviducts, ducts or funnels carrying female gametes, usually from the coelomic funnel to or towards the exterior on 14.

Ovum (*pl.* ova), an unfertilized egg.

Palaearctic, zoogeographic region comprising Europe and Mediterranean north of Sahara through to Asia north of Himalayas (i.e., north Atlantic to north Pacific Oceans).

Pangea (Pangaea), supercontinent that began to rift in the Triassic into Laurasia and Gondwana.

Paraphyletic (or Paraphylic) taxon, a group which includes the most recent common ancestor of all those organisms and some, but not all, of that ancestor's descendents. Paraphyletic taxa are recognized in Linnean and evolutionary systematics but not in cladistics. In cladistics an otherwise monophyletic group of species is rendered 'paraphyletic' when a branch (clade) has been removed because it subsequently gave rise to a derived (apomorphic) group. For instance, the Class Reptilia would become paraphyletic as is gave rise to mammals and birds, but neither mammals nor birds are included under Reptilia. Other examples are found in the Invertebrates, Amphibia, Dinosauria (if birds are excluded), Gymnosperma, etc. As Mayr (1998) shows us

"*Paraphyly does not occur in Darwinian class*ification" which, he cogently reminds us, deals with balanced groups of related organisms rather than mere extirpated branches ("clades") of the phylogenetic tree.

Parieties, body wall of a segment.

Parthenogenesis, uniparental reproduction in which the ovum develops without fertilization by spermatozoa.

Parthenogenetic of or pertaining to that manner of reproduction.

Penial setae, setae associated with proatatic or male pores - see seta.

Peptonephridia, classical term for organs, supposedly modified nephridia, opening into the buccal cavity or pharynx (see pharyngeal mass, salivary glands; tufted nephridia).

Peregrine, exotic, widely distributed, foreign. In the past, often with the implication of widely wandering but now usually more accurately characterized as anthropochorous.

Perichaetin(e), location of the setae, when more than eight per (setigerous) segment, often in a more or less complete circle around the equator, *cf.* lumbricine; anisochaetine.

Periproct, preferred to pygomere (*q.v.*) by some because of similarity to peristomium. Anal segment at tail end.

Peristomium, anteriormost portion of the body, around the mouth and, like the pygomere, lacking major characteristics of a segment, such as setae, though counted as segment one.

'Pharyngeal gland-cells' are not gland-cells in the usual sense, and do not communicate with the pharynx; the term 'chromophil cells' was proposed for them by Stephenson (1917) because of their intense coloration by hæmatoxylin and similar stains. The so-called 'septal glands' are aggregations of similar cells at a more posterior level.

Pharyngeal mass, of peptonephridia and pharyngeal gland cells in the pharyngeal region.

Pharynx, the anterior of the alimentary canal between mouth and the oesophagus (includes buccal cavity) = "pharyngeal region".

Pheretimoid, a member of the genus *Pheretima auct./s. lat.*, typically with gizzard in 8, male pores on 18, single female pore on 14, clitellum restricted to 14-16, spermathecae in or anterior to 9/10, meroic, perichaetine setae with slight mid-ventral setal gap and often with intestinal caeca.

Phylogenetic, phylogeny, having to do with past evolutionary development, as distinct from ontogenetic.

Plesiomorphic, plesiomorphy, a character or structure that is evolutionarily primitive or ancestral. Cf. apomorphic.

Polyandric, having testes in more segments than 10-11.

Polydiverticulate, with reference to spermathecae, having more than two diverticula per segment.

Polygiceriate, with several gizzards; e.g. digiceriate, trigiceriate.

Polygonadal, having more than four gonads.

Polymorphic, of or pertaining to polymorphism. The latter, with reference to megadriles, is of several kinds, of which the most important for systematics are geographical and parthenogenetic.

Polyoculate, referring to a spermathecal diverticulum, having several seminal chambers.

Polyphyletic, of mixed evolutionary origin, not derived from a common ancestor.

Polyphyletic (or Polyphylic) taxon, a group with some similarities that does not include the probable most recent common ancestor of all members (usually because that ancestor lacks some or all of the characteristics of the group). Polyphyletic taxa often share derived characters which originated separately by convergence, and are considered invalid or unnatural groupings, unacceptable in either the Linnean/Evolutionary or the Cladistics taxonomies.

Polyploid, having more than two sets of homologous chromosomes, *cf.* diploid, haploid.

Polyprostatic, having more than six prostates in three segments or more than eight in two segments.

Polystomate, having many mouths, referring to nephridia, with several nephrostomes.

Polytesticulate, having more than two pairs of testes.

Polythecal, having more than one or two pairs of spermathecae per segment.

Porophore, any area, protuberance or special structure bearing a pore, usually that of a spermatheca, ovi-duct or sperm-duct, the latter being the male porophore.

Posterobiprostatic, with prostates in 19 after loss of a pair in 17 of an acanthodriline set.

Precis or *Précis*, key features in specific or generic definition, a term similar to diagnosis.

Proandric, proandry, classical term meaning testes restricted to 10 or a homoeotic equivalent, the state of being such.

Progenitor (or primogenitor), an ancestor of direct lineage.

Progynous, progyny, a classical term meaning ovaries restricted to 12 or a homoeotic equivalent, the state of being such.

Prolobic, prolobous, characterizing a prostomium demarcated from and without a tongue

in prostomium.

Prostate, paired glands found in several families of earthworms, either associated with the vas deferens or opening with separate ducts near male pores. Their exact functions are largely unknown - probably they produce a fluid for the transport (and nourishment?) of sperm during (and after) copulation; interestingly, they appear to correspond in size with the combined volume of spermathecal pouches (pers. obs.). Tubular prostates have a central lumen and open beside, or within a segment or two of the male pores in acanthodrilids, ocnerodrilids and octochaetids. Tubular to racemose glands in megascolecids are usually combined with the male pore. Racemose glands have no central lumen, rather a system of branching ductlets. Intermediate glands, appearing lobular but with varying degrees of branching from the internal lumina are termed tubuloracemose. Prostate also applies to the moniligastrid capsular glands and the eudrilid "euprostates". Lumbricid 'prostates', without stalks are characterised as "atrial glands". There are now just two categories of megascolecoid prostates (after Michaelsen, 1907; Blakemore, 2000): **tubular**, as found in the more 'primitive' families and genera, and "**non-tubular**" which is any other kind of development from the tubular.

Prostatic duct, a duct from the prostatic gland (see Prostate above) to the male pore. These ducts are often muscular and thus may force or ejaculate the prostatic fluid (collecting semen from the vas deferentia) into partner's receptacles (spermathecae).

Prostomium, a protuberance anteriorly and above the mouth from the first segment. A sensory and prehensile appendage for probing and enforlding ingesta.

Protandric, protandrous, proterandrous, having sperm maturing before ova. Protandry, the state of being such.

Proventriculus, see crop.

Proximal, near to, towards, place of attachment, as in a regenerate, an organ on a septum, the gut, or body wall.

Pseudogamic, of or pertaining to pseudogamy, a method of reproduction in which entrance of the sperm stimulates development of the egg but without involving biparental heredity.

Pseudovesicles, structures on posterior faces of 12/13 or 13/14 that are serially homologous with seminal vesicles. Usually retained from an embryonic or early juvenile state. Function unknown.

Pygomere, the terminal portion of the body, sometimes called the anal segment but lacking some of the characters of a metamere.

Quadriprostatic, with four prostates.

Quadrithecal, with four spermathecae.

Quiescence (quiescent), a temporary state of inactivity caused by adverse conditions, *cf.* diapause.

Quincunx, an alternating pattern of setae so they are offset from one segment to the next somewhat like the “five” pattern on a dice:

Racemose, from the latin *racemus*, meaning bunch, as perhaps of grapes, long used to characterize the lobular kind of prostate present in *Pheretima s. lat.* and related genera. Lobulation may or may not be obvious superficially but within those glands a prostatic duct branches repeatedly, the subdivisions usually unrecognizable macroscopically, *cf.* tubular, tubuloracemose. See ‘prostate’.

Regressed, a post-adult, aclitellate stage (physiological response to environmental stress?).

Regularization, anatomical adjustments involved in reducing the asymmetry resulting in unilateral splitting of mesoblastic somites.

Rodinia, supercontinent that began to rift apart no later than 750 million years ago before reforming in different configurations as Pannotia and later as Pangaea

Salivary glands, in classical writings a term for organs, opening into the buccal cavity or the pharynx, that sometimes were thought to be modified excretory organs = peptonephridia/tufted nephridia.

Saprovores, deriving energy primarily from ingesting dead plant materials.

Schizolobous, prostomium where two longitudinal furrows continue to diverge some distance beyond the transvers furrow that bisects them (cf. tanylobous in *L. terrestris*).

Scolecophagous, scolecophagy [Greek scoleco-, worm; phagein, to eat], worm-feeding; two meanings: one, you eat the worm; two, the worm eats you.

Segment, a portion of the body, along the anteroposterior axis, between two consecutive intersegmental furrows and the associated septa (also somite, metamere).

Septa (sing. septum), internal partitions between segments.

Seminal, literally of or pertaining to seeds, but characterizing structures in which sperm are involved.

Seminal vesicles, pockets from a septum in which sperm are matured. Seminal vesicles supposedly in 10, as well sometimes as in 11, in some species of *Pheretima s. lat.*, have been testis sacs, of ocnerodrilid genera have been hypertrophied testes. The septal outgrowth may be simple, tubular, lobed with connective tissue partitions internally. Often in 9 and 10 on anterior faces of the septa, in 11 and 12 on posterior faces of septa.

Seminal reservoirs, in some older publications, see seminal vesicles.

Seminal furrows or grooves, except in the Lumbricidae, referring to distinct and permanent markings in the epidermis that are associated with male, and sometimes also prostatic pores, and through which sperm and/or prostatic secretions move at time of

copulation.

Seminal receptacles, formerly used for spermathecae or occasionally even for seminal vesicles.

Septum (*pl.* septa), two layers of peritoneal cells enclosing muscle fibres, connective tissue and blood vessels separating adjacent segments. Usually delicate but sometimes thickened or muscular between anterior segments.

Seta (*pl.* setae), from Latin meaning bristle, hence more appropriate than chaeta Greek meaning hair or mane. Solid rods, secreted by cells at ental end of a tubular epidermal ingrowth, the setal follicle. Follicles are provided with protractor and retractor muscles so that the seta can be partially protruded or retracted to aid locomotion. A normal, unspecialized seta has a slight double curvature providing a sigmoid shape, a pointed outer end called the tip, a thickening somewhere near the middle of the shaft called the nodulus, and a blunt inner end called the base. Specialized setae, usually no longer sigmoid, often ornamented in one or more of several ways, if associated more or less closely with male or prostatic pores are called penial setae, that probably function to remove or disrupt sperm stored in the spermathecae from previous concopulants. Copulatory setae are those associated with the spermathecae. Modified setae associated with genital tumescences and/or with special glands but not especially with the male, female, prostatic or spermathecal pores are designated only as genital. These types of setae grip and stimulate concopulants during mating. These setae often are variously modified in shape and may be sculptured (ornamented) ectally in numerous ways. Ornamentation by circles of fine spines or teeth may also characterize enlarged setae at either end of the body. Traditionally, setae have been important to the classification of earthworms, especially the division between lumbricine and perichaetine. However, reliance on precise setal ratios to separate lumbricine taxa is not advisable as there is much intraspecific variability depending on factors such as preservation technique. Similarly, using details of ornamentation of modified setae to differentiate species is often impractical for most workers and there is also intraspecific variation, sometimes even within the setal bundles of a specimen. Setae, as with nephridia and prostates, come in just two varieties or forms (after Michaelsen, 1907; Blakemore, 2000): lumbricine and non-lumbricine.

Setigerous, normally bearing setae.

Sexprostatic, with 6 prostates in 3 consecutive segments (rare or abnormal).

Sexthecal, with 3 pairs of spermathecae.

Somatic, of or pertaining to any portion of the anatomy except the reproductive organs.

Somites, alternative name for segments (see metamere).

Sperm duct, ducts or tubes that carry sperm from the male funnel to or towards the exterior (=vas deferens).

Sperm sacs, in writing of some classical authorities, seminal vesicles, or sometimes referring to testis sacs or spermathecae.

Spermatheca (*pl.* spermathecae), spermathecal, an often flask-shaped organ in which sperm, received from a copulatory partner, are stored until fertilization of ova in cocoons. The ectal region is often slender and forms the duct (which may support diverticula), while the ental region is dilated to form the ampulla. Number, form and location of the spermathecae is of systematic import.

Spermatophore, a packet of spermatozoa usually transferred to concopulants especially in species lacking spermathecae.

Spermiducal glands, spermiducal pores, of older texts are prostates and prostatic pores.

Stomate, having a mouth, referring to a nephridium, with a funnel. A nephridium with a funnel sometimes is said to be "open".

Sub-adult, large immature without secondary sexual markings or regressed mature.

Sulcate, having seminal furrows or grooves.

Synapomorphy, an apomorphy that is shared by two or more species or groups, so it is plausible that they are related evolutionarily. Cladograms (cf. phylogenetic trees) are built by discovering groups united by synapomorphies, i.e., forming a strictly monophyletic clade (the basis of cladistics); for example feathers are unique to birds and define the class Aves. Equivalent to homology, i.e., similarity due to common evolutionary origin. Cf. autapomorphy, homoplasy, symplesiomorphy.

Synonym, each of two or more names of the same rank used to denote the same taxon.

Synonymy, the relationship between synonyms and a list of taxonomic synonyms.

Symplesiomorphy, possession of a character state that is primitive (plesiomorphic) and shared between two or more taxa thus is not evidence that the taxa are related but diagnostic of a paraphyletic group, cf. synapomorphy. Cladistic terms.

Tanylobous, characterizing a prostomium with a tongue that reaches all the way through first segment to 1/2.

Taxon (*pl.* taxa), any unit in a system of classifying of plants or animals.

Testicular vesicle, sometimes mistaken, when enlarged in parthenogenetic morphs for seminal vesicles.

Testicular chamber, testis sac.

Testicular sac, testis sac or some part of it.

Testis sac, usually a closed off coelomic space containing one or both testis and male funnels of a segment.

Tethys Sea, the sea separating Laurasia from Gondwana following the disintegration of

Pangaea in the Mesozoic.

Thecal, having spermatheca.

Topsoil dwellers, Lee's (1959) ecological category for worms living in the topsoil.

Trabeculate, characterizing megadrile seminal vesicles that develop as connective tissue proliferations from a septum so as to have numerous irregular spaces that remain inconsiderable until spermatogonia (male germ cells) begin to enter.

Tribe – a taxonomic rank, presumably below Sub-family and above Super-genus, that often was an indication of indecision or insufficient understanding; ending is –ini.

Troglophile, cave loving.

Trogloxene, cave guest.

Tubercula pubertatis (*sing.* tuberculum pubertatis), paired papillose or ridge-like tumescences forming genital pads in the clitellar region of reproductive adults (mainly lumbricids), used to grip partner.

Tubular, prostate form where tube-like glandular portion has central lumen on bisection. See 'prostates'.

Tubuloracemose, prostatic glands with a central lumen, from which short branches pass out, intermediate between the simpler tubular kind (without such branches) and the racemose, polylobular glands (without a central or macroscopically recognisable lumen). These types of prostates were called "strap-like" in some earlier works. See 'prostates'.

Tufted nephridia, found in both holoic and meroic species, are complex holonephridia that often discharge into the buccal cavity (see peptonephridia; salivary glands).

Typhlosolate, having a typhlosole, usually with reference to a segment or segments of the intestine or the intestinal region of the body.

Typhlosole, any longitudinal fold of gut wall, especially if projecting into the gut lumen from the roof at mD or the floor at mV. Lateral typhlosoles (in the intestine) usually are rudimentary. Increases the surface area of intestine for digestion.

Unidiverticulate, having one diverticulum, as of spermathecae.

Uniloculate, having only one seminal chamber, as of spermathecal diverticulum.

Varieties, from ICZN (1999 Art.15.2): A new name published after 1960 expressly as the name of a "variety" or "form" is deemed to be infrasubspecific and as such is not regulated by the Code [Art. 1.1.1] and is excluded from its provisions [Arts. 1.3.4, 45.6.3]. 15.2.1. Names published before 1961 for "varieties" or "forms" - see Art. 45.6.4.

Vas deferens (*pl.* vasa deferentia), sperm duct(s).

Ventral blood vessel, large trunk below gut, carrying blood posteriorly.

Vermiculture, breeding and culturing of worms.

Vesicle, referring to the excretory system, the bladder; referring to the reproductive system, anteriorly or posteriorly directed pockets of a septum in which male germ cells mature.

Vesiculate, with reference to a nephridium - provided with a bladder; with reference to a reproductive system - having seminal vesicles; with reference to tissue or organ structure - having small spaces.

Vestibulate, having one or two vestibula.

Vestibulum (*pl.* vestibula), an invagination in some species (e.g. *Eutyphoeus*) that contains a penis or male porophore, regardless of whether it is confined to the body wall or reaches more or less conspicuously into the coelom. Not homologous with, but containing the male pore fissure.

Zygolobous, a prostomium not demarcated from the peristomium.

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Appendix I: Further refinement of subfamilies of Megascolecidae : Oligochaeta

Suborder Lumbricina De Blainville, 1828, classed as Terricolae Örsted, 1843 or, most appropriately, as Megadrili Benham, 1890, now constructed as Class Megadrilacea , for all 'megadriles' including Moniligastridae. See Blakemore (2013) for family revisions.

Contingency table of characters and sub-families of Megascolecidae Rosa, 1891

Setae per segment	Nephridia	Prostates	Sub-family with Priority	Representative type sp
8	Holoic	Tubular	**Pontodrilinae /** **Plutellinae** Vejdovsky, 1884	*Pontodrilus marionis* Perrier, 1874 / *Plutellus heteroporus* Perrier, 1873
8	Meroic	Non-tubular	**Cryptodrilinae** Beddard, 1890: 236 / 1891: 256*	*Cryptodrilus rusticus* Fletcher, 1886
>8	Holoic	Non-tubular	**Perionycinae** Benham, 1890 (as Perionycidae)	*Perionyx excavatus* Perrier, 1872
>8	Meroic	Non-tubular	**Megascolecinae** Rosa, 1891**	*Megascolex caeruleus* Templeton, 1844

*Intermediate genera such as *Megascolides* M'Coy, 1878 or *Driloleirus* Fender & McKey-Fender, 1990 – i.e., lumbricine, meroic species with tubular prostates (Blakemore, 1997a; 2000c) – belong here or in a new/revived sub-famies (Megascolidinae and/or Driloleirinae?).

**Synonymic Perichaetidae Claus, 1880 for *Perichaeta leucocycla* Schmarda, 1861 that, although probably still an available name, should be avoided for nomenclatural stability – see my notes above on Perichaetidae homonymy and see also Blakemore (2013).

Appendix II : Gilbert White's quote on Earthworms in his *Natural History of Selborne* (1789):

"*Letter XXXV To The Honourable Daines Barrington Selborne, May 20, 1777.*

Dear Sir,

Lands that are subject to frequent inundations are always poor; and probably the reason may be because the worms are drowned. The most insignificant insects and reptiles are of much more consequence, and have much more influence in the Economy nature, than the incurious are aware of; and are mighty in their effect, from their minuteness, which renders them less an object of attention; and from their numbers and fecundity. Earth-worms, though in appearance a small and despicable link in the chain of nature, yet, if lost, would make a lamentable chasm. For, to say nothing of half the birds, and some quadrupeds, which are almost entirely supported by them, worms seem to be the great promoters of vegetation, which would proceed but lamely without them, by boring, perforating, and loosening the soil, and rendering it pervious to rains and the fibres of plants, by drawing straws and stalks of leaves and twigs into it; and, most of all, by throwing up such infinite numbers of lumps of

earth called worm-casts, which, being their excrement, is a fine manure for grain and grass. Worms probably provide new soil for hills and slopes where the rain washes the earth away; and they affect slopes, probably to avoid being flooded. Gardeners and farmers express their detestation of worms; the former because they render their walks unsightly, and make them much work: and the latter because, as they think, worms eat their green corn. But these men would find that the earth without worms would soon become cold, hard-bound, and void of fermentation; and consequently sterile: and besides, in favour of worms, it should be hinted that green corn, plants, and flowers, are not so much injured by them as by many species of coleoptera (scarabs), and tipulae (long-legs), in their larva, or grub-state; and by unnoticed myriads of small shell-less snails, called slugs, which silently and imperceptibly make amazing havoc in the field and garden. (* Farmer Young, of Norton-farm, says that this spring (1777) about four acres of his wheat in one field was entirely destroyed by slugs, which swarmed on the blades of corn, and devoured it as fast as it sprang.) These hints we think proper to throw out in order to set the inquisitive and discerning to work. A good monography of worms would afford much entertainment and information at the same time, and would open a large and new field in natural history. Worms work most in the spring; but by no means lie torpid in the dead months; are out every mild night in the winter, as any person may be convinced that will take the pains to examine his grass-plots with a candle; are hermaphrodites, and* ***much addicted to venery****, and consequently very prolific.*

I am, etc."

G. White Esq.

Appendix III Liste complète des travaux de Wilhelm Michaelsen [from Wikipedia]

NOTE: Michaelsen's material (types) in Berlin (ZMB) and Hamburg (Senckenberg), etc. are listed online here (Ref.) or here - http://www.biodiversitylibrary.org/creator/45318#/sections ; or here (Ref.).

1885-1889

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- 2. 1886. Über Enchytraeus moebii, Mich., und andere Enchytraeiden. Kiel: 1886.
- 3. 1886. Über Chylusgefäss systeme bei Enchytraeiden. Archiv für Mikroskopische Anatomie, Bonn 28: 292-304, 21 pls.
- 4. 1887. Enchytraeiden-Studien. Archiv für Mikroskopische Anatomie, Bonn 30: 366-378, 21 pl. (Translated in The Annals of Natural History, London (5), 20: 417-427).
- 5. 1888. Die Oligochaeten von Süd-Georgien. Jahrbuch der Hamburg 5: 55-72.
- 6. 1889. Die Gophyreen von Süd-Georgien nach der Ausbeute der Deutschen Station von 1882-1883. Jahrbuch der Hamburg 6: 70-84, 1 pl.
- 7. 1889. Oligochaeten des Naturhistorischen Museums in Hamburg. I. Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten, Hamburg 6: 1-17, 1 pl.
- 8. 1889. Oligochaeten des Naturhistorischen Museums in Hamburg. II. Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten, Hamburg 6: 59-69, 2 pls.
- 9. 1889. Synopsis der Enchytraeiden. Abhandlungen der Gesellschaft, Hamburg 11: 1-60, 1 pl.

1890-1894

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- 14. 1891. Oligochaeten des Naturhistorischen Museums in Hamburg. IV. Jahrbuch der Hamburg 8: 42, 1 pl.
- 15. 1891. Beschreibung der von Herrn Dr. Fr. Stuhlmann auf Sansibar und dem gegenüberleigenden Festlandes gesammelten Terricolon. I. Übersicht über die Telendrilenen. II. Die Terricolen-Fauna Afrikas. Mitteilungen aus dem Naturhistorischen Museum in Hamburg 9: 3-72, 4 pls.
- 16. 1891. Terricolen der Berliner Zoologischen Sammlung. I. Afrika. Archiv für Naturgeschichte, Johannesburg 57: 205-228, Taf. 8.
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- 18. 1892. Beschreibung der von Herrn Dr. Fr. Stuhlmann am Victoria Nyanza gesammelten Terricolen. Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten 9(2): 29-42, 1 pl.

- 19. 1982. Terricolen der Berliner Zoologischen Sammlung (II). Archiv für Naturgeschichte, Berlin 57(2): 209-261, 13 pls. + 5 woodcuts.
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- 21. 1894. Die Regenwurm-Fauna von Florida und Georgia. Zoologische Jahrbücher, Abteilung für Systematik, Jena 10:177-194.
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1895-1899

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- 29. 1897. Die Terricolen des Madagassischen Inselgebiets. Abhandlungen hrsg. von der Senckenbergischen Naturforschenden Gesellschaft, Frankfurt a. Main 21: 217-252, 3 pls.
- 30. 1897. Die Polychaetenfauna der deutschen Moore einschliesslich der benachbarten und verbindenden Gebiete. Wissenschaftliche Meeresuntersuchgen der Kommission zur Wissenschaften Untersuchung der Deutschen Meere, Kiel & Leipzig (Neue Folge) 2(1): 1-216, Taf.1
- 31. 1897. Die Terricolenfauna Ceylons. Aus Natur und Museum, Frankfurt a. Main 14: 157-250, 1 pl.
- 32. 1897. Neue und wenig bekannte afrikanische Terricolen. Mitteilungen aus dem Naturhistorischen Museum in Hamburg 14: 1-71, pl. 1.
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- 35. 1898. Über eine neue Gattung und vier neue Arten der Unterfamilie Benhamini. 2 Beiheft Jahrbuch der Hamburgischen Wissenschaftliche Anstalten, Hamburg 15: 163-178, 5 figs.
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  Volume 16 of Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten: Wissenschaftliche Anstalten des Staates Hamburg
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- 36. 1899. Beitrage zur Kenntniss der Oligochäten. Zoologische Jahrbücher, Abteilung für Systematik, Jena 12: 105-144, 2 figs.

- 37. 1899. Revision der Kinbergischen Oligochaeten-Typen. Ofversigt Akademiens Fšrhandlingar, Stockholm 56: 413-448, 3 figs.
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- 41. 1900. Die Lumbriciden-Fauna Nordamerikas. Abhandlungen der Gesellschaft, Hamburg 16: 22 pp.
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- 49. 1902. Die Lumbriciden-Fauna Norwegens und ihre Beziehungen. Abdruck Verhandelingen der Naturwissenschaftlichen Vereins zu Hamburg 9(3): 1-13.
- 50. 1902. Die Oligochätenfauna des Baikal-Sees. Abdruck Verhandelingen der Naturwissenschaftlichen Vereins zu Hamburg 9(3): 43-60.
- 51. 1902. Der Einfluss der Eiszeit auf die Verbreitung der Regenwürmer. Abdruck Verhandelingen der Naturwissenschaftlichen Vereins zu Hamburg 9(3): 62-65.
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- 58. 1903. Die Oligochäten der Deutschen Tiefsee - Expedition nebst Erörterung der Terricolenfauna oceanischer Inseln; insbesondere der Inseln der subantarktischen meere. Wissenschaftliche Ergebnisse der Deutschen Tiefsee - Expedition auf dem Dampfer *Valdivia*, Jena 3, 4: 133, 22 pls.
- 59. 1903. Eine neue Haplotaxiden - Art und andere Oligochaeten aus dem Telezkischen See im nördlichen Altai. Verhandlungen des Vereins für Naturwissenschaftliche Unterhaltung zu Hamburg 10(3): 1-7.
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- 61. 1903. Oligochäten von Paradeniya auf Ceylon, ein Beitrag zur Kenntnis des Einflusses botanischer Gärten auf die Einschleppung peregriner Thiere. SB Böhmisch. Ges. Wiss. 55: 16 pp., 16 figs.
- 62. 1904. Revision der composition Styeliden oder Polyzoiner. Mitteilungen aus dem Naturhistorischen Museum in Hamburg 21: 1-124.
- 63. 1904. Über eine Triniphrus - Art von Ceylon. Mitteilungen aus dem Naturhistorischen Museum in Hamburg 21: 125-131.

1905-1909

- 64. 1905. Die Oligochaeten der deutschen Tief-See Expedition. Deutsche Südpolar Expedition, Ergebnisse 3: 133-166.
- 65. 1905. Catalogo de los Oligoquetos del territorio chileno-magallanico i descripción de especies nuevas. Revista Chilena de Historia Natural, Santiago de Chili 8: 262-322.
- 66. 1905. Die Oligochäten des Baikal-Sees. Wissenschaftliche Ergebnisse einer zoologischen Expedition nach dem Baikal-See unter Leitung von Alexis Korotneff i D.J., 1900-1902. Erste Leifarung. Kiew und Berlin: R. Friedländer und Sohn, 69 pp.
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- 71. 1907. Zur Kenntnis der deutschen Lumbriciden fauna. Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten, Hamburg 24 (1906), 2: 189-193.
- 72. 1907. Regenwürmer von Erythraea nach der Ausbeute des Herrn Dr. K. Escherich. Verhandelingen des Vereins für Naturwissenschaftliche Unterhaltung zu Hamburg 13(1905-1907): 5-15.
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- 78. 1907. Oligochaeten von Australien. Abhandlungen aus dem Gebiete der Naturwissenschaften, Hamburg 30(1): mit 1 Tafel und 9 Abbildungen im Text.
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- 93. 1910. Die Oligochäten des inneren Ostafrikas und ihre geographischen Beziehungen. Wissenschaftliche Ergebnisse des Deutschen Zentral-Afrika Expedition 1907-8, Leipzig 3: 1-90 [Leipzig: Klinkhardt & Biermann].
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Appendix IIII **Benham, W.B. publications**

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Appendix V Liste complète des travaux de Gordon Enoch Gates [from Wikipedia]

ALSO CHECK THIS PARTIAL LIBRARY OF G.E.GATES http://www.biodiversitylibrary.org/creator/44138/author#/sections

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1975-1979[modifier]

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1980-1982[modifier]

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From Wikipedia

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Table 8. Non-endemic spp (~154 taxa) in Pacific cf. North American & India regions. (Family classification after Blakemore, 2000)

FAMILIES (origins) and *Species* from selected Regions	Aust. (excl. Tas.)	Tas.	N.Z.	Japan (excl. Ryu-kus)	Ryu-kyu Isls.	Korea (inc. Jeju Isl.)	Taiwan	China (incl. Hainan)	SE Asia	U.S.A. & Canada	Mexico	Hawaii	P.I.	India & Sri Lanka	Myanmar (Burma)
MONILIGASTRIDAE (Oriental & Indian)															
Desmogaster sinensis Gates, 1930								+							
Drawida barwelli (Beddard, 1886)	*			+		*?		*(H)	+		+		+		+
Drawida impertusa Stephenson, 19203									+						
Drawida japonica (Michaelsen, 1892)				+		+	+	+	+						
Drawida longatria longatria Gates, 1925									+						+
Drawida nepalensis Michaelsen, 1907								+	+						+
GLOSSOSCOLECIDAE (Neotropical)															
Pontoscolex corethrurus (Müller, 1857)	++(CI)		+	+(BI)	*		+	+	+	+	+	+	+	+	+
ALMIDAE (Tropics)															
Glyphidrilus papillatus (Rosa, 1890)								+(H) ?	+?					+?	+?
HORMOGASTRIDAE (Mediterranean)															
Hormogaster redii Rosa, 1887										+					
CRIODRILIDAE (S-W Palaearctic)															
Criodrilus lacuum Hoffmeister, 1845										+				+?	
SPARGANOPHILIDAE (Nearctic)															
Sparganophilidae tamesis Benham, 1892											+?				
LUMBRICIDAE (Holarctic)															

Allolobophora chlorotica (Savigny, 1826)	+	*	+									+		+								
Allolobophoridella eiseni (Levinsen, 1884)		*	+									+				+			+			
Aporrectodea caliginosa (Savigny, 1826)	+	+	+	+			+		+?		+			+		+		+				
Aporrectodea icterica (Savigny, 1826)												+										
Aporrectodea limicola (Michaelsen, 1890)	B+											+				+						
Aporrectodea longa (Ude, 1885)	+	+	+									+		+								
Aporrectodea rosea (Savigny, 1826)	+	+	+	+			+			+		+		+		+			+			
Aporrectodea trapezoides (Dugès, 1828)	+	+	+	+			+		+	+	+	+		+		+			+			
Aporrectodea tuberculata (Eisen, 1874)	+		+	+?			+		+?	+?		+		+					+			
Bimastos parvus (Eisen, 1874)	+		+?	+		*	+		+	+	+	+?		+		+			+		+	
Bimastos tumidus (Eisen, 1874)														+								
Dendrobaena attemsi (Michaelsen, 1903)	?	?	*									+										
Dendrobaena hortensis (Michaelsen, 1890)	B+	*										+							+			
Dendrobaena octaedra (Savigny, 1826)				+						+?		+		+		+			+			
Dendrobaena pygmaea (Savigny, 1826)				*								+										
Dendrobaena veneta veneta (Rosa, 1886)	B+		*	*								+										
Dendrodrilus rubidus rubidus (Savigny, 1826)	+	*	+	+			+			+		+		+		+			+			
D. rubidus subrubicundus (Eisen, 1874)	+		+	?+								+?										
D. rubidus tenuis (Eisen, 1874)	+(HI)	+(MI)		+			+			+?		+?		+								
Eisenia anzac Blakemore, 2011				*					+?													

Eisenia fetida andrei Bouché, 1972	+?		+?	+?	+?				+?	+?	+?				
Eisenia fetida fetida (Savigny, 1826)	+	*	+	+	+	*	+	+	+	+	+	+	+		
Eisenia japonica (Michaelsen, 1892) sub-spp				+?	+	+	+?								
Eisenia j. vaga Blakemore, 2012			*												
Eisenia nordenskioldi (Eisen, 1879) sub-spp. **Emend.**					+		+				+?				
Eisenia nordenskioldi pallida Malevics, 1956					+?		+?								
Eiseniella neapolitana (Örley, 1885)									+						
Eiseniella tetraedra (Savigny, 1826)	+	+	+	*		*			+	+			+		
Eophila eti Blakemore, 2007		+													
Eophila moebii (Michaelsen, 1895)										+					
Eophila molleri (Rosa, 1889: 3)										+?					
Helodrilus (=*Eisenia*) *hachiojii* (Blakemore, 2007)				+?											
Lumbricus castaneus (Savigny, 1826)	*	*	+						+	+			+		
Lumbricus festivus (Savigny, 1826)	+?								+						
Lumbricus friendi Cognetti, 1904									+						
Lumbricus rubellus Hoffmeister, 1843	+	+	+		+??				+	+			+		
Lumbricus terrestris Linnaeus, 1758	??	*	+	*	+??				+	+			+		
Murchieona minuscula (Rosa, 1906)									+?						
Murchieona muldali (Omodeo, 1956)			*						+?						
Octolasion cyaneum (Savigny, 1826)	+	+	+						+	+			+	+	
Octolasion t. lacteum (Örley, 1881)	*?		+				+		+	+			+	+	
O. t. tyrtaeum (Savigny, 1826)	+		*				+?		+	+			+		
Satchellius mammalis (Savigny, 1826)									+						
OCNERODRILIDAE (Tropical															

America & Africa)																		
Gordiodrilus elegans Beddard, 1892	*									+						+	+	
Nematogenia panamaensis (Eisen, 1900)										+						+		
Ocnerodrilus occidentalis Eisen, 1878	*	*		+	+	*			+	+	+		+	+		+	+	
Eukerria kuekenthali (Michaelsen, 1908)	+(CI)									+						+	+	
Eukerria saltensis (Beddard, 1895)	+	*?		*		*	+		+	+	+		+			+	+	
Malabaria levis (Chen, 1938)									+(H)	+						?	+	
Thatonia exilis Gates, 1945										+								
Thatonia gracilis Gates, 1942										+							+	
ACANTHODRILIDAE (Pangaean?)																		
Microscolex dubius (Fletcher, 1887)	+	*	+?	*							+		+			+		
Microscolex kerguelarum (Grube, 1877)	+(HI)																	
Microscolex macquariensis (Beddard, 1896)		+(MI)																
Microscolex phosphoreus (Dugès, 1837)	+	*	+	+							+		+		+		+	
Rhododrilus kermadecensis Benham, 1905	B+?	*													+			
Rhododrilus queenslandicus Michaelsen, 1916	+																	
Rhododrilus sp. north Queensland	+?																	
Yagansia longiseta (Beddard, 1895)											+?							
OCTOCHAETIDAE (Circumtropical, plus Indo-Australasia)																		
Dichogaster affinis (Michaelsen, 1890)	*						+		+(H)	+	+		+		+	+	+	
Dichogaster annae (Horst, 1893)	*									+			+			+	+	
Dichogaster bolaui (Michaelsen, 1891)	++(CI)				+	*	+		+(H)	+	+		+	+	+	+	+	

Dichogaster corticis (Michaelsen, 1899)										+									
Dichogaster modiglianii (Rosa, 1896)	+(CI)		?+							+	+		+	+					
Dichogaster reinckei Michaelsen, 1898															+?				
Dichogaster saliens (Beddard, 1893)	*+(CI)				+		+			+	+		+			+	+		
Dichogaster sp. nov? in NT	*																		
Lennogaster pusillus (Stephenson, 1920)										+									
Octochaetona beatrix (Beddard, 1902)	*									+							+		
Octochaetona surensis (Michaelsen, 1910)																	+		
Ramiella bishambari (Stephenson, 1914)	+(CI)							+		+							+		
MEGASCOLECIDAE (mostly Indo-Australasian)																			
Argilophilus marmoratus Eisen, 1893	??																		
Pontodrilus litoralis (Grube, 1855)	+		+	+	+	*	*	+(H)+		+	+		+	+		+	+		
Pontodrilus primoris Blakemore, 2000		*?																	
Perionyx excavatus Perrier, 1872	*	*	*	+		+	+			+	+		+	+		+?	+		
Perionyx macintoshii Beddard, 1883																	+		
Perionyx violaceus Horst, 1893										+									
Amynthas agrestis (Goto & Hatai, 1899)						+?					+								
Amynthas aeruginosus Kinberg, 1867													+	+					
Amynthas alexandri Beddard, 1901																+	+		
Amynthas asiaticus Michaelsen,							+?			+?									

1900																		
Amynthas aspergillum (Perrier, 1872)				+?	+		+	+?	+									
Amynthas assacceus (Chen, 1938)					+?		+?	+?										
Amynthas carnosus carnosus (Goto & Hatai, 1899)				+?		+?	+?	+?	+?									
Amynthas c. roki Blakemore, 2013						*		*										
Amynthas corticis (Kinberg, 1867)	+	*	+	+	+	+	+	+?	+	+		+		+		+		+
Amynthas glabrus (Gates, 1932)				+	+			+	+									+
Amynthas gracilis (Kinberg, 1867)	+		+	+	+	*	+	+?	+	+		+		+		+		+
Amynthas gracilis insularum Blakemore, 2012				*		*												
Amynthas hupeiensis (Michaelsen, 1895)	+(T)?		+	+	+	+	+	+?	+	+								
Amynthas incongruus (Chen, 1933)							+	+?										
Amynthas lautus (Ude, 1905) - possibly synonym of *A. robustus*					+?		+?	+?										
Amynthas lavangguanus (Gates, 1959)														+?	+			
Amynthas loveridgei (Gates, 1968)										+								
Amynthas manicatus (Gates, 1931)									+?									
Amynthas minimus (Horst, 1893)	+			+	+		+	+?	+	+				+	+			+
Amynthas morrisi (Beddard, 1892)	+			+	+		+	+?	+	+		+		+		+		+
Amynthas p. papilio (Gates, 1930)							+											
Amynthas papulosus (Rosa, 1896)				+	+		+	+?	+									+
Amynthas perkinsi (Beddard, 1896)														+?				
Amynthas rechingeri (Cognetti, 1909)														+				
Amynthas robustus (Perrier, 1872)				+	+	+	+	+?	+							+		+
Amynthas rodericensis (Grube, 1879)	+ +(CI)			+				+?	+	+					+			+
Amynthas taipeiensis (Tsai, 1964)							+?	+?										
Amynthas talus Blakemore, 2014	*																	
Amynthas tralfamadore Blakemore,						*		*										

| | | |

Metaphire hilgendorfi (Michaelsen, 1892)					+?				+		+					
Metaphire houlleti (Perrier, 1872)	+					+		+?	+		+		+		+	+
Metaphire javanica (Kinberg, 1867)	??							+?	+?							
Metaphire malayana (Beddard, 1900)																+?
Metaphire pajana (Michaelsen, 1928)									+							
Metaphire peguana (Rosa, 1890)			+?						+						+	+
Metaphire planata (Gates, 1926)									+?						+	+
Metaphire posthuma (Vaillant, 1868)	+(CI)					+		+?	+	+	+				+	+
Metaphire ryunome Blakemore, 2012			***?**		*****			*****								
?*Metaphire sandvicensis* (Beddard, 1896) [?= *M. californica*]								+?				+?				
Metaphire soulensis (Kobayashi, 1938)			+?		+?											
Metaphire virgo (Beddard, 1901)									+?							+?
Notoscolex javanica (Michaelsen, 1910)																+
Notoscolex pumila (Stephenson, 1931)																+
Pheretima darnleiensis (Fletcher, 1886/7)	+(T,CI)								+				+			
Pheretima montana Kinberg, 1867									+				+			
Pithemera bicincta (Perrier, 1875)	++(CI)		+		*	+		+	+	+	+	+	+	+	+	+
Polypheretima annulata (Horst, 1883)									+							
Polypheretima brevis (Rosa, 1898)	+(CI)												+			
Polypheretima elongata (Perrier, 1872)	+				+	+			+	+?	+	+	+	+	+	+
Polypheretima taprobanae (Beddard, 1892)	+										+	+	+	+	+	+
Polypheretima voeltzkowi (Michaelsen, 1907)													+			
EUDRILIDAE (West African)																

Eudrilus eugeniae (Kinberg, 1867)	*								+	+						
Total non-endemic exotic spp. (E)	66	28	35	42	21	37	34	51	59+	62	47	33	30	50	50
Endemic natives in region (N)	449	202	193	<82	12	70	47	196	?	121	57	0	20	455	135
Approx. TOTAL spp. (E+N)	515	230	228	<124?	33	97	81	247	?	183	104	33	50	505	185
Exotics [E/(E+N)] Approx %	**12.8**	**11.7**	**14.0**	**50.0**	**64.3**	**30.0**	**42.0**	**19.7**	?	**33.0**	**44.6**	**100**	**60.0**	**9.9**	**27.0**
Region	Aust	Tas.	N.Z.	Japan	Ryu-kus	Korea	Taiwan	China	SE Asia	USA & Canada	Mexico	Hawaii	P.I.	India	Myanmar
Approximates:															
Lumbricidae as % total exotic	35%	60%	69%	~42%	2	58%	20%	29%	6%	53%	46%	33%	10%	34%	4%
Megascolecidae as % total exotic	35%	18%	22%	~46%	72%	39%	73%	51%	63%	28%	26%	51%	66%	34%	56%

Abbrvns.:- Aust. – Mainland Australia; Tas. - Tasmania; N.Z. - New Zealand; P.I. Pacific Islands.

Codes:- **+ -** present as a non-endemic species; ***** - first records from author's (R.J. Blakemore) studies; ? - indicates some ambiguity of taxonomic description, endemicity (e.g. possiblity that the taxon is native to a region), or veracity of report; ??- false report; B - J. C. Buckerfield pers. comm.; (BI) Bonin Island; (CI) Christmas Island; (H) Hainan; (HI) Heard and McDonald Islands; (MI) Macquarie Island; (T) Torres Straits Islands. P.I. - Pacific Isles [Fiji, Samoa, Tonga, Niue I., Kermadec, Vanuatu, Solomons, Cook Is., Tahiti, Marianas, Marshalls, Carolines, Marquesas, New Caledonia with Loyalty Is. - these reports compiled from Easton (1984), Lee (1981) and pers. obs.].

For Australia as a whole (i.e., mainland + Tasmania), totals are ca. 715 species with about 67-69 exotic (ca. 9%) and, of these ca. 35% Lumbricidae (~3% of total spp).

North American data are for continental U.S.A. and Canada – from the Arctic Ocean south to the Rio Grande but excluding offshore islands, whence Blakemore (2005) recognized 180 species in ca. 40 genera from 12 families; Hawaiian records are also derived from Blakemore (2005).

India (and adjacent countries) and Myanmar records are derived from Julka (1988: 39, Table 2), Gates (1972), Stephenson (1923) and various other sources (Blakemore, 2006, 2008, etc.).

Notes:

The above table is adapted from Blakemore (1994, 1999, 2000, 2002, 2003, 2004, 2005, 2006, 2008, 2012, 2016; Blakemore *et al.*, 2006, 2007) and various other sources e.g. Michaelsen (1900), Gates (1972, 1982), Lee (1985, 1987), Tsai *et al.* (2000), etc..

Rosa's *constricta*, once part of *Bimastos parvus* (syn. *beddardi* Mich) is now included in the synonymy of *Dendrodrilus rubidus*. The report of *Bimastos parvus* from N.Z. by Sims & Gerard (1999: 48) is possibly a mistake for this or is one of the native species called "parva", but it is also reported as an introduced species to Yukon Territory, Canada. *Lumbricus festivus* has an unconfirmed report from Australia by Gerard (1964: 47). *Rhododrilus kermadecensis* seems endemic to Kermadec Islands, N.Z.. The genus *Pontodrilus* may have originated in the Indo-Australasia region (see Blakemore, 2000, 2007). *Anisochaeta spp.* and *Didymogaster* are genera endemic to Australia. Specimens of *Amynthas indicus* (Horst, 1883) listed from Christmas Island (and Torres Straits?) were said by Sims & Easton (1972: 263) to be *Pheretima darnleiensis.* Easton (1981) considered *Amynthas lautus* a synonym of *A. robustus*, but Tsai *et al*. (2000: 286) disagree. *Metaphire javanica* is possibly synonymous with *M. californica* that has page priority, whereas *Pithemera bicincta* may comprise more than one taxon (pers. obs.), e.g. its synonym *Pithemera violacea* (Beddard, 1895) perhaps merits specific status.

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2015 International Year of Soils

and

World Soil Day

December 5th 2015, both passing without much fanfare... as for each subsequent year.

Never mind; an excellent organic, soil and health online library resource for us is here:-

http://journeytoforever.org/farm_library/howard_memorial.html

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